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ARCHIVES OF SURGERY

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RADIO-ULNAR SYNOSTOSIS *

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AND
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* This study was begun in 1921 in collaboration with Dr. Henry Ling Taylor, at that time associated with the Hospital for Crippled and Ruptured, New York. Many circumstances have led to delay in publication: the necessity for prolonged field work; the pressure of other work previously begun. At last, when the analysis was nearly completed, came the serious illness followed by the death, of Dr. Taylor, in consequence of which the senior author has been forced to assume unexpected responsibility of the results.

This study was initiated by a series of cases that came to the clinic of Dr. Taylor, who has provided clinical descriptions of each propositus. The detailed study of the family history in these cases was made by Miss Louise A. Nelson of the Eugenics Record Office of the Carnegie Institution of Washington, Cold Spring Harbor, N. Y. The literature on the subject was looked up and abstracted by Miss Mabel L. Earle of the Eugenics Record Office. For the general discussions and the final form of the whole, C. B. Davenport, Carnegie Institution of Washington, is responsible. Especial thanks are due to Dr. D. D. Ashley for introducing us to the Pa. family (No. 11), and for the use of the roentgenograms relating thereto.

I. INTRODUCTION

Radio-ulnar synostosis, or congenital synostosis of the proximal ends of the radius and ulna, also sometimes called "congenital pronation," is a condition rarely found in one or both forearms of which the most obvious symptom is an inability to hold the hand supine; i. e., with the palm upward. The condition is a variable one, both in the degree of interference with supination and complete pronation, of associated limitations in the functioning of the arm, and, as revealed by roentgenograms, in the extent and nature of the synostosis. In order to describe these variations intelligently, a brief description of the parts involved may be useful.

Figure 1 *a* is an outline of a roentgenogram of the elbow of a 13-year-old boy seen from the side. The radius lies somewhat above the plane of the ulna. The neck and head are visible. To the latter, an epiphysis will eventually become attached. The epiphysis which forms the tip of the olecranon is not yet fused with the latter. At the distal end of the humerus is the ossification center of the "capitellum," the contact surface with the radius; also of the trochlear and internal condyle.

Figure 1 *b* shows the bones of the same region in the right arm of a 12-year-old girl, viewed from the front, when the arm is held in the supinate position, so that radius and ulna are as nearly parallel as possible. The radius is seen to overlie, to a certain extent, the ulna. Just below the neck of the radius, one sees an enlargement, the bicipital tubercle.

In the normal forearm, when held in the pronated position, the radius crosses from its connections near the lateral margin of the humerus toward the radial margin of the hand, which now lies mesiad. In the condition of proximal synostosis of radius and ulna, the two bones are fused in an incompletely decussated position so that complete supination (with its implication of parallel bones) is no longer possible.

Radio-ulnar synostosis is a rare condition, though new cases are being found more rapidly since the introduction of roentgenography. Baisch [1] (pp. 50-51) gave a list of thirty-eight cases which had been described in the literature up to that time; and nearly as many more have been described in the ten years since. In most described cases, the condition is said to have been congenital; and, indeed, it is frequently noticed in early infancy. It is found in both arms in about half the cases, and it is not infrequently recorded that one or more of the relatives of the patient show a similar defect. It is therefore quite certain that the

1. Baisch, B.: Die kongenitale radio-ulnare Synostose, Ztschr. f. orthop. Chir. **31**:46-57, 1912.

condition is constitutional, and is not to be ascribed merely to some intra-uterine injury, to a repression exercised by an external agent during development, or to some inflammatory disease that has led to a secondary ankylosis of tissue that was originally developed normally.

In treating the subject further, it is proposed (1) to describe a number of new cases; (2) to consider the types into which these cases fall; (3) to treat of the development of the arm bones in relation to the defect; (4) to consider its phylogenetic bearings; (5) to examine the question of defects associated with synostosis, and, finally, (6) to study the hereditary factors that may be involved.

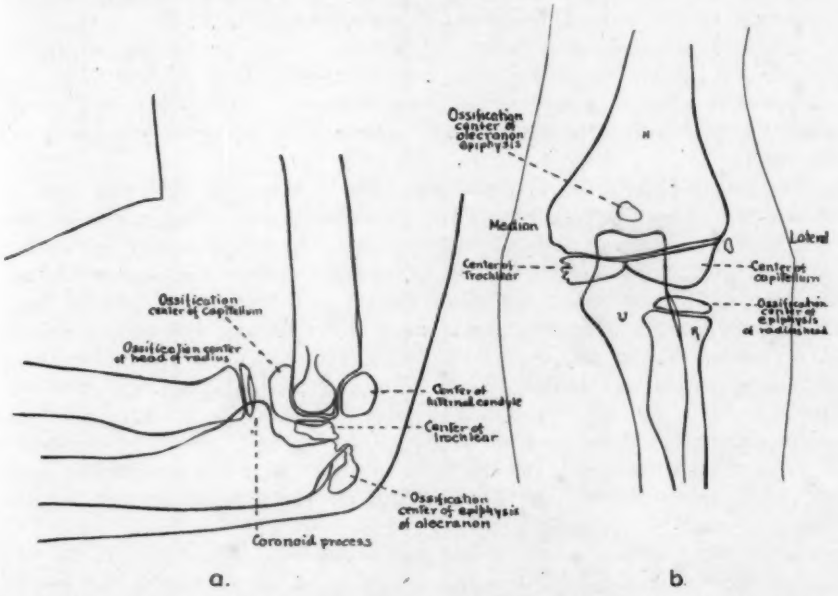

Fig. 1.—Outline of roentgenograms of normal arm at elbow: *a*, flexed arm of 13-year-old boy viewed perpendicular to sagittal plane of body; *b*, extended arm of 12-year-old girl, viewed from ab-olecranal (ventral) aspect. (From Wilms: Die Entwickelung der Knochen der Extremitatem von der Geburt bis zum vollendeten Wachstun oberes Extremitat. Arch. der normalen u. pathologischen Anatomie in typischer Roentgenbildern, Fortschr. a. d. Gebiete d. Roentgenstrahlen (supplement).

II. DESCRIPTICN OF NEW CASES BY FAMILIES

1. *M. Family.*—The propositus (Fig. 2, IV 15), a boy, aged 9 years, born Dec. 16, 1913, at St. Louis, a full term baby of normal birth, weighing 3.4 kg., during infancy was healthy, and during childhood had only the usual diseases of that period and made good recoveries. From early childhood, he could not turn his palms up in order to receive an object handed to him; and to the present time he was unable to supinate either hand. He could pronate both hands (right, pronation 135 degrees; left, 90 degrees) and he could lift and

carry heavy weights. The arms could be flexed normally, but extension was limited (on right, greatest extension, 150 degrees; on left, greatest extension, 160 degrees). He made such compensations that his home and school duties were in no way interfered with; indeed, except for an awkwardness in handling knife, fork, spoon and cup at table, the condition inconvenienced him little. It had been diagnosed by Dr. Taylor at the Hospital for the Relief of Ruptured and Crippled as bilateral radio-ulnar synostosis. It was accompanied by no other physical defect except flat feet. The boy appeared to be of good mentality. He was short for his age, and slender, and apparently quite healthy.

From the roentgenogram (Figures 3 and 4) it appears that in the right arm the radius, while not bowed, did not make the normal contact with the distal end of the humerus but was fused with the ulna. On the left side, the region of fusion was greater. Also, the olecranon seemed not to be entirely of normal form. At least, it showed no coronoid process.

The boy belonged to a family of Russian Jews, comprising intelligent, industrious and thrifty people, who were prosperous in a material way and ambitious to educate themselves and their children. The boy had two sisters, aged 8 and 7 years respectively, who appeared to be entirely normal and healthy.

The father (Fig. 2, III 12), who was born in Minsk, in 1889, was short in stature and physically very strong, but immediately after birth, it was noticed that he had a bilateral radio-ulnar synostosis. He was a painter by occupation and had always worked steadily at his trade without the slightest inconvenience until eight years ago when he began to experience pain in both elbows and found it difficult to grasp or lift objects of any considerable weight. Examination showed that both arms were very short. While flexion was normal, extension was limited (right, 155 degrees; left, 155 degrees), and the hands could be rotated only half way from full pronation to full supination (right pronation, 120 degrees; left pronation, 70 degrees). Small articles could be received in either palm, and the knife and fork were not used in the same way as by other people. Dr. Taylor found the radial heads present but not well developed.

The father had four brothers and two sisters:

One sister (Fig. 2, III 2), born 1876, was not seen, as she lived in California. The father stated that she was normal and healthy in all respects. She had two children (by her first marriage), both normal.

A brother (Fig. 2, III 4) was also not seen, as he lives in Minsk. He was said to be normal except that he also showed a bilateral radio-ulnar synostosis, which was evident at birth. The ability to supinate was absent in both hands. He, too, was short in stature, but very strong physically. By occupation, he was a painter, and he found himself in no way inconvenienced in his work by his deformity. He married a normal woman and had seven children, two boys and five girls. It was noted that both boys at birth, had a bilateral radio-ulnar synostosis, and both lacked entirely the ability to supinate. The girls were said to be entirely normal.

Another brother (Fig. 2, III 6), who lived in Odessa, was said to be normal in all respects except for a bilateral radio-ulnar synostosis, which was first noted at birth. The ability to supinate was lacking in both hands. He, too, was a painter. He married a woman who had the normal capacity for supinating. They had four children. The two boys had a bilateral radio-ulnar synostosis, lacking the ability to supinate either hand.

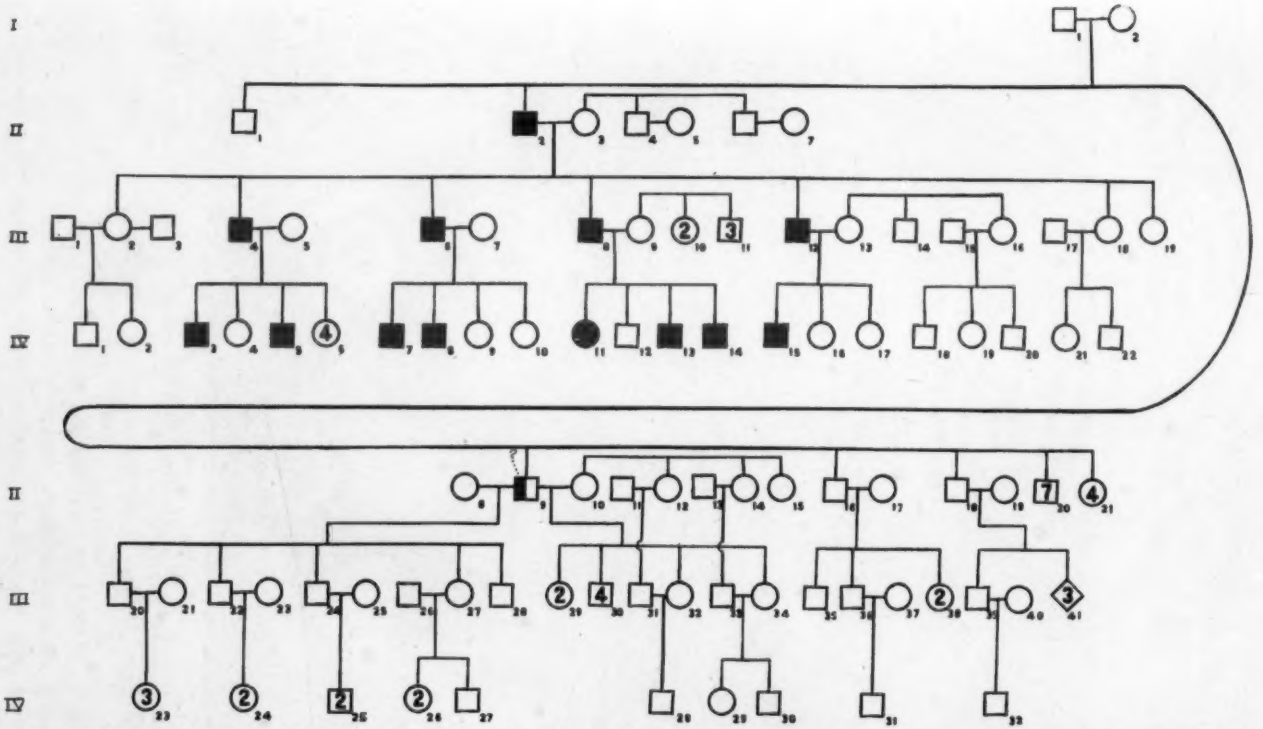

Fig. 2.—Pedigree chart of M. family: In this and the following charts, Roman numerals represent generations, arabic numerals, individuals. The squares represent males; the circles, females; black symbols, synostotic individuals; half-black, those unilaterally affected. The large figures inside of symbols indicate the designated number of that sex. The line of Generation II is carried down to a second level to conserve space.

A third brother (Fig. 2, III 8), born in Minsk, 1888, lived in East New York. He was able to give us data concerning his brothers in Russia and their children. This man, a typical Russian Jew in appearance, seemed entirely normal except for a bilateral radio-ulnar synostosis, which was apparent even at birth. He was a painter and paper hanger by occupation and found himself little inconvenienced by his deformity. His arms were unsymmetrical. The left arm was 2 inches (5 cm.) shorter than the right and lacked the capacity

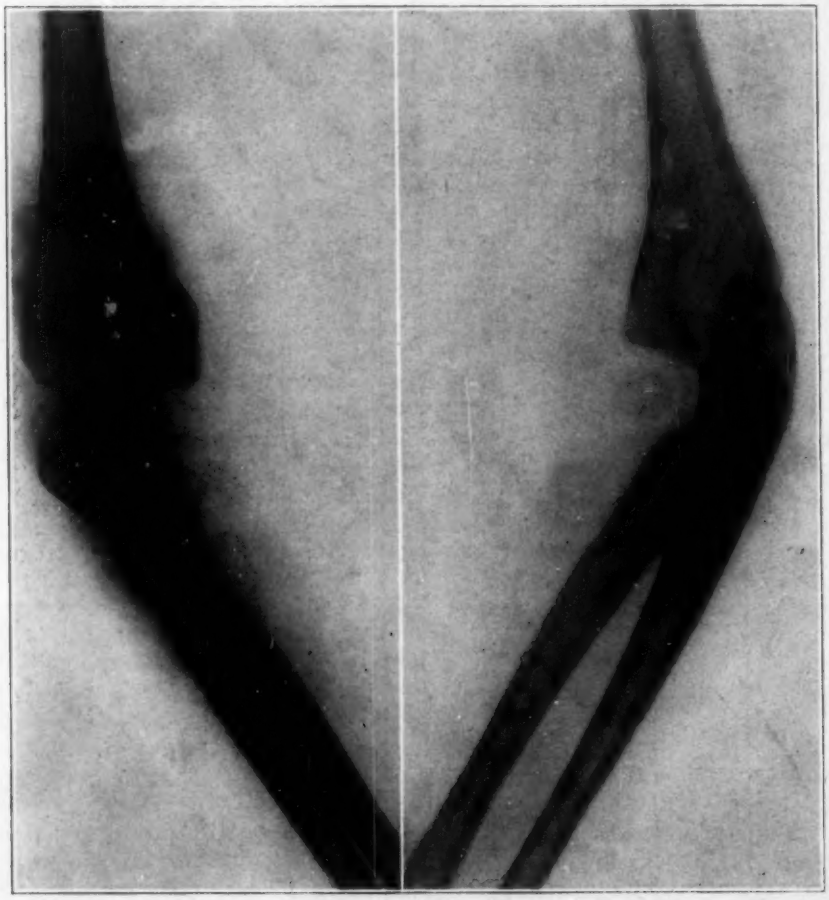

Fig. 3.—Arms of K. M., showing bilateral synostosis and persistence of the radial element.

for supination. It could be normally flexed; but extended only to 135 degrees. The right arm possessed a slight degree of supination and could be extended to 160 degrees. He married a normal woman of normal stock, and they had four children:

(*a*) A girl (Fig. 2, IV-11), born in New York City in 1911, a delicate child subject to severe headaches and otitis from the age of 3 years, at birth was observed to have, a bilateral radio-ulnar synostosis. She was the only girl

so affected in this family, which contained, altogether, fourteen persons with the deformity. In ordinary activities, she experienced little inconvenience from the deformity, but the power of supination was absent in both hands, and she could not raise either palm to receive a small article in them. A the table, she found it impossible to handle her fork and spoon as other people do. Flexion appeared to be normal. Extension was limited in the right arm to 140 degrees, in the left to 135 degrees.

(*b*) A boy (Fig. 2, IV-12), born in New York City in 1914, died at 2 years of age of convulsions. He is said to have had no radio-ulnar synostosis.

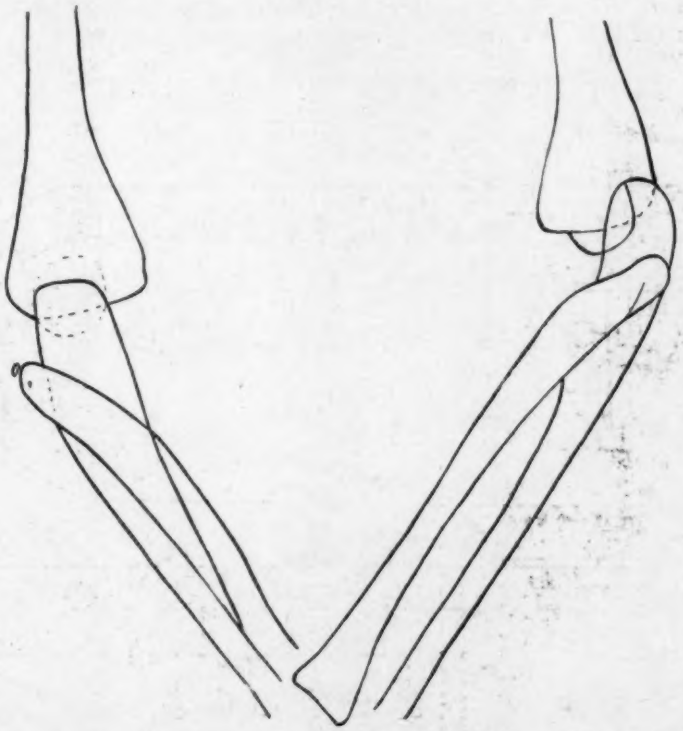

Fig. 4.—Outline of roentgenogram of propositus in M. family, a boy, aged 9 years. The right arm is approximately in the sagittal plane. The left elbow is in fronto-anterior projection. In the right arm, the absence of head, neck and tuberosity of the radius may be noted, also absence of the coronoid process. The capitellum is in contact with the humerus. The left side shows the ossification center for the capitellum radii somewhat late for a child of 9 years. The ossification center for the internal epicondylus is not yet evident. However, the contour of the outer condyle is clear.

(*c*) A boy (Fig. 2, IV-13), born in 1916, died a the age of 4 years of bronchial pneumonia. He had a bilateral radio-ulnar synostosis, with no capacity of supination.

(*d*) A boy (Fig. 2, IV-14), born in 1917, a normal healthy child except for bilateral radio-ulnar synostosis, had no power of supination. Flexion appeared to be normal, but extension was limited in both arms to 140 degrees.

The other sister (Fig. 2, III-18), born in Minsk and still living there, was said not to be affected by radio-ulnar synostosis nor were her husband or any of their seven children affected.

The paternal grandfather of the propositus (Fig. 2, II-2) was born in Minsk in 1836, and died, in Russia, at the age of 80 years. He was second in order of birth of sixteen children, all but two of whom were said to be normal. He himself had a bilateral radio-ulnar synostosis, which was probably not noted at birth, since there was handed down in the family a tradition that it resulted from an accident. He had no ability to supinate the hand, and the capacity for extending the forarm was limited. He was by occupation a farmer. He was very short of stature and of heavy build, weighing 180 pounds (82 kg.). He was possessed of great physical strength.

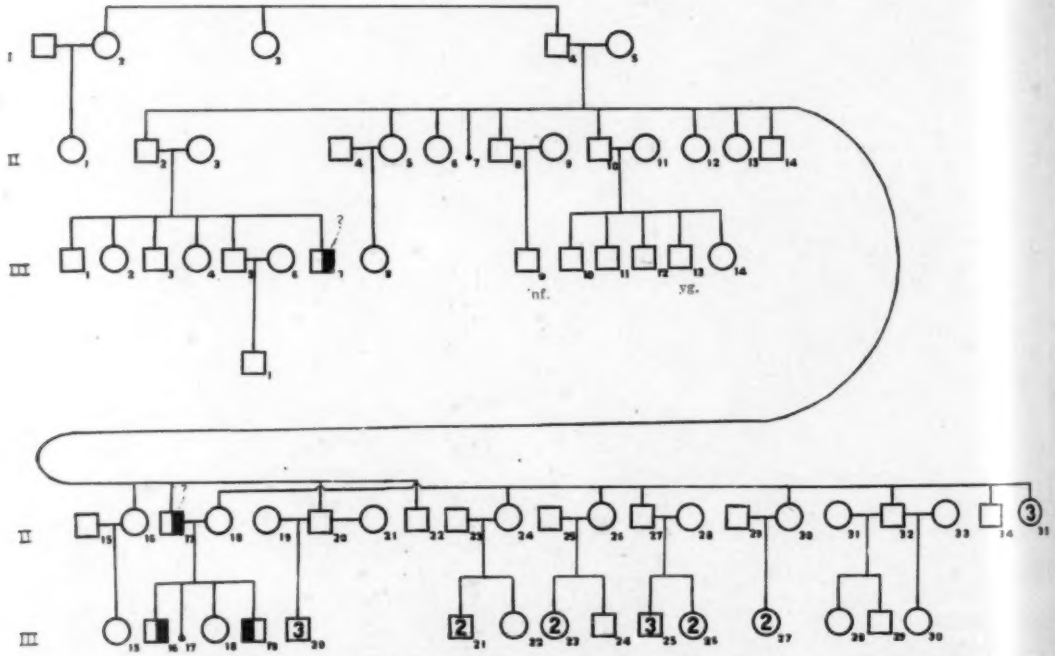

Fig. 5.—Pedigree chart of R. family: inf., died in infancy; yg, died young. Half black symbols indicate unilateral (dextral or sinistral) synostosis.

The next younger brother to the preceding was born in Minsk and emmigrated to the United States for the first time several years ago. He died at Mount Sinai Hospital of carcoma of the pharynx at the probable age of 69 years, though his death certificate gives his age at 60 years, probably in harmony with the age given by him on his admission schedule. By occupation he was a carpenter. He was short of stature and was very strong physically (Fig. 2, II 9).

The evidence concerning his bony condition was somewhat conflicting. Those of his nephews in this country who were affected with bilateral radio-ulnar synostosis stated that he unquestionably had one crooked arm and probably two. His son and daughters, all of whom so far as seen, were free from the defect, denied this statement. However, the statements of his children were probably biased, since they uniformly expressed the fear that the information

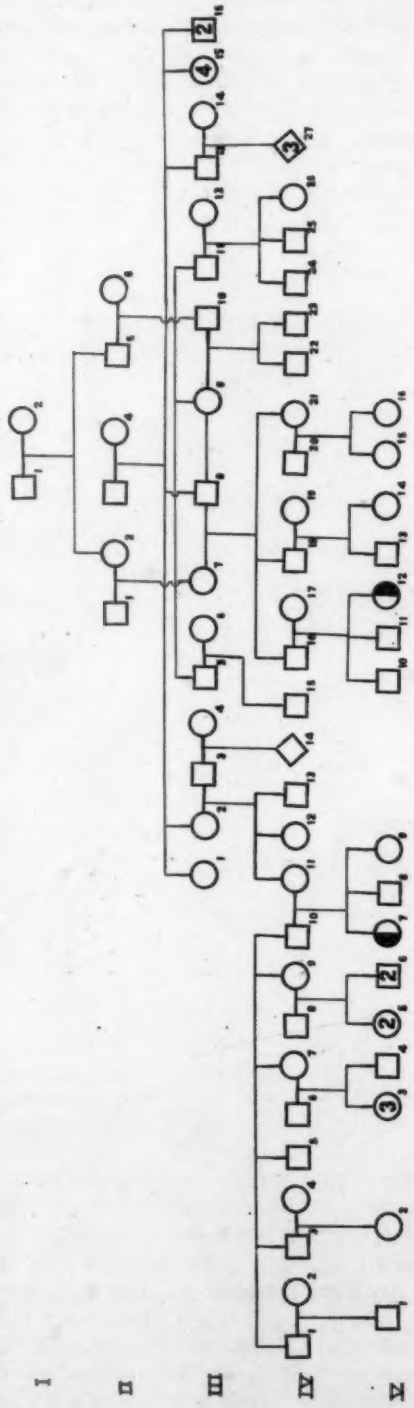

Fig. 6.—Pedigree chart of A. family.

sought by the investigator was to be used to return them to Russia "as descendants of a cripple," the more so because the father and the mother entered this country by fraud. The case is recorded on the chart as a possible synostotic one; but the absence of the defect in his descendants makes it improbable that he was such.

This man (Fig. 2, II-9) married twice. The first wife was said to have been normal. Her five children were:

A son (Fig. 2, III-23), born at Minsk in 1872, and seen in New York City, whither he came in 1905, was short of stature and dark, like an Italian. Physically, he was very strong. He had a tendency to bowing of the bones of the

Fig. 7.—Appearance of S. A., showing functional adaptation of left arm to the synostotic handicap. The right arm supinates perfectly.

lower legs, and he stood on the outer margins rather than on the soles of the feet. His wife stated that this was because when young, he set at his work with his feet crossed under him, tailor-fashion. He had also what appeared to be a small bony horn-shaped protuberance on his right temple. Evidently he, like his father, had something of disostosis and exostosis. He was a man of normal intelligence, and conducted his business of dealer in magazines and newspapers, with profit. He married a woman of normal bony development who had epilepsy. They had three children, of whom the youngest had a violent temper.

The second son (Fig. 2, III-25), born in Russia in 1875, and who lived in Los Angeles, had two children. They were all said to be normal as to bony development.

A third son (Fig. 2, III-27) was also in the United States. He was short in stature. He had two sons, and none of this branch of the family had marked bone defects.

A daughter (Fig. 2, III-30), had three children, all of whom were said to be normal in their skeletal growth. The same was true of the remaining child, who was drowned at the age of 20 years.

The second wife (Fig. 2, II-10), a woman of normal skeletal development, had eight children, of whom some were seen, and for all radio-ulnar synostosis was denied. It was certainly not present in those seen.

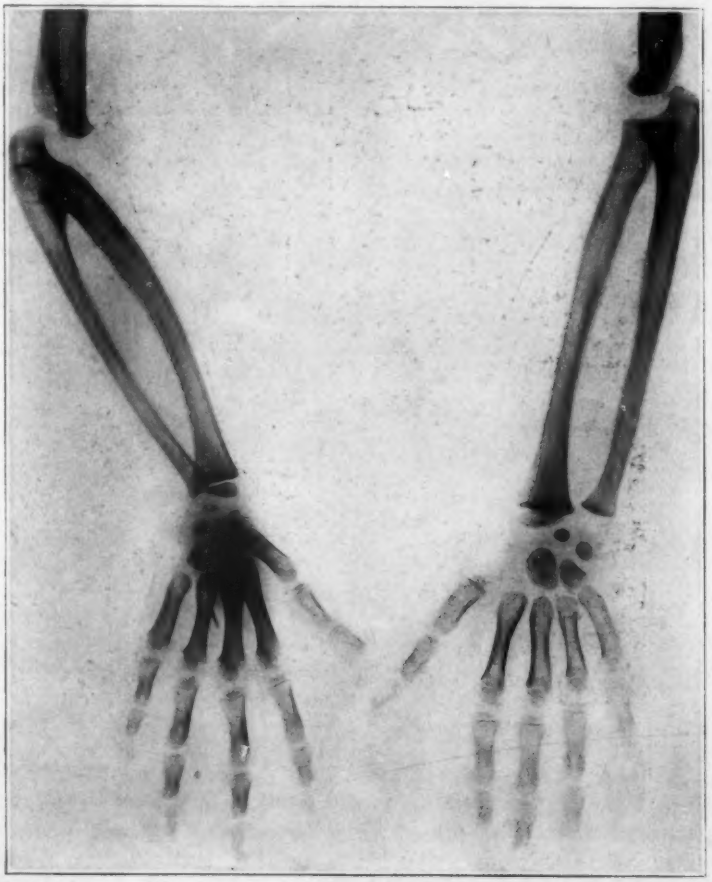

Fig. 8.—Elbows, forearms and hands of S. A. showing synostosis in left arm and marked bowing of left radius.

A brother (Fig. 2, II-16) of the husband (Fig. 2, II-9) of these women was tall, slender and very strong. He had four children, all of whom were like himself, devoid of bony abnormality.

Another brother (Fig. 2, II-18) was also tall and free from bony maldevelopment, as were his four children. There were numerous other members of this family, but for all of them it was denied that there was any trace of bony synostosis.

The father of this family (Fig. 2, I-1), was born in Minsk. He was a farmer, and strong and active. It was said that he had no skeletal defects (Eugenics Record Office Archives: F, **73**:892-904).

2. *R. Family.*—The propositus (Fig. 5, II-19), a member of a New York family of Irish extraction and of Catholic faith, born, Sept. 29, 1918, was a full-time baby of normal birth, weighing 10 pounds (4.5 kg.). At 15 months, he learned to walk and, at two years, to say a few words. It was probable that he, at 3 years, was of subnormal intelligence, since he had been slow in learning to talk, and had a dull stupid expression in his eyes and a vacant stare. He seemed well nourished and his chin was deeply dimpled. He had had chickenpox, and whooping cough without sequelae, but at 18 months he had an abscess of the right ear, which left him slightly deaf.

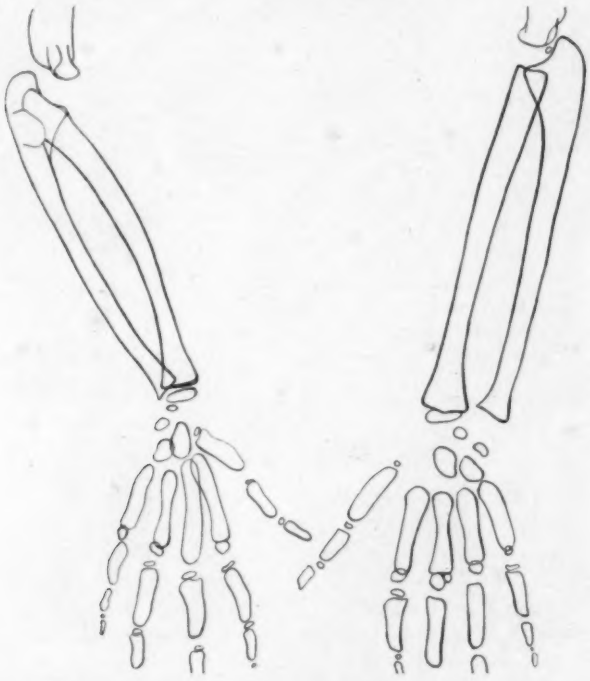

Fig. 9.—Outline of roentgenogram of arms and hands of S. A., aged 8 years: In the right arm, the eminentia capitata is already attached to the humerus. The capitellum radii has begun to ossify. The minute ossification center near the proximal end of the ulna is possibly that of the trochlea, since this makes its appearance at 8 or 9 years. The left arm shows the same ossification center close to the distal end of the humerus. The coronoid process is already well marked. The bowing of the radius is marked on the left arm.

At the age of 3 months, his mother noticed that he could not supinate his left hand, nor could she do it for him when she washed his hands. He was first taken to the orthopedic hospital clinic for examination, when 21 months old. A roentgenogram taken, August 21, revealed an anterior bowing of the left radius, and a union of the radius with the ulna at the site of the tubercle of the radius. The record of the orthopedic hospital on this case is as follows:

"General condition good, speech defect, teeth good, tonsils small. Heart negative, lungs negative, abdomen slightly protuberant, spine straight and flexible. Upper right arm, normal. Upper left arm: Shoulders normal. Forearm completely pronated, all power to supinate arm or further pronate it is lost, due to synarthrosis of upper end of the radius and ulna. Flexion and extension at the elbow good. Muscle power apparently normal in arm and forearm. Wrist, normal motion and muscle power. Hand negative. Lowers: Negative. Diagnosis: Radio-ulnar synostosis."

The same month, he was operated on by Dr. Durham at the orthopedic hospital, and an incision 3 inches (7.5 cm.) long made on the dorsum of the arm between the proximal ends of the ulna and radius. Both bones were exposed and proximal ends of the radius were found overlying the ulna and completely fused to it for a distance of about 1 inch (2.5 cm.) from head of the radius. The two bones were separated with a chisel, after which supination was still impossible. The head and about three-quarters inch (1.9 cm.) of shaft of the radius was resected, which allowed about 90 degrees of rotation. The interosseus membrane was sutured over the end of the radius. The wound was closed in layers with catgut. The skin was closed with silkworm. The arm was put in supination with the elbow held at right angles.

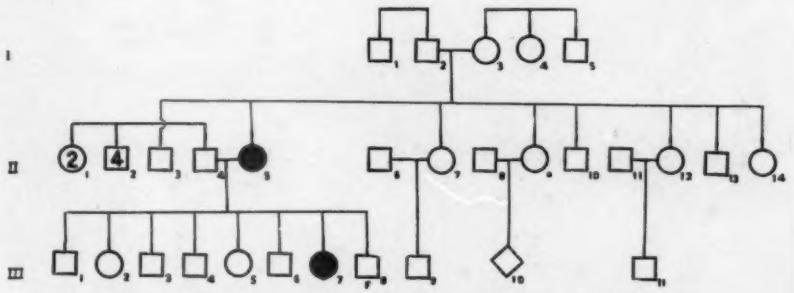

Fig. 10.—Pedigree chart of L. family: 6, feebleminded.

September 8, a second roentgenogram showed that the proximal end of left radius, about the size of a pea, had been removed at operation. The position of the end of radius relative to ulna appear unchanged in the lateral view. An anterioposterior view not obtained because of the cast.

September 28, examination showed 5 degrees of free motion in the radius. Supination was possible beyond the midposition.

A few weeks later, about two-thirds normal flexion and extention was possible and about 5 degrees of supination.

The brother of the above described boy (Fig. 5, III-16), born in New York City in 1909, a full-term baby of normal birth weighing 9 pounds (4 kg.), was well developed and well nourished. He had blue eyes and fair hair, and was well formed in every way except for a slight right radio-ulnar synostosis. The hand and arm were held half way between pronation and supination, and the hand could not be supinated. He is awkward in handling his knife, fork, spoon and cup at the table and "shoveled" his food at the table because of the defect. The arm rotated from the shoulder only. Beyond his awkwardness in handling things, he was in no way incapacitated by this condition. He was a fairly good athlete.

While the mother thought the condition congenital, the father considered it due to an accident that befell the child at the age of 7 or 8, when he fell

from an apple tree and hung for some time by this arm, which had previously been broken. The father, however, is not certain which arm had been broken, and as all symptoms pointed to a typical case of radio-ulnar syntosis, it was charted as such.

He had a dimple in his chin, and also one in cheek. Mentally, he appeared to be normal. He was in the 6B grade, but was not fond of study, and has been kept back twice.

The remaining pregnancies were:

A miscarriage (Fig. 5, III-17) at 2 months in 1912, and a daughter (Fig. 5, III-18) born in 1914, a full-term baby of normal birth weighing 7 pounds (3.2 kg.). At 7 years, she was slender, well developed, well formed, had always been well and appeared to be normal in all respects. She was in the 2B grade.

The father of this family (Fig. 5, II-17) was born in New York City in 1883. He was well developed and well formed, 5 feet and 9 inches (1.77 meters) tall, and was well except for a slight degree of nephritis. His wife

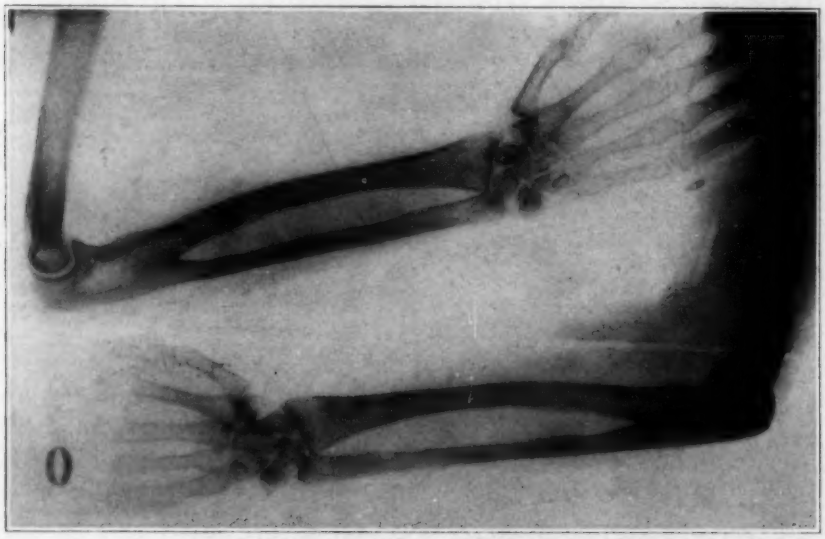

Fig. 11.—Arms of Mrs. L., showing bilateral radio-ulnar synostosis.

stated that his right arm showed the same defect as his sons' arms, but to a much less degree, so that he was only slightly awkward in handling his knife, fork and spoon at the table.

Casual observation revealed no inability in supination or in extension and flexion. There seemed to be a slight deviation from the normal at the shoulder. The right hand was supinated. He said that no awkwardness was experienced in using the hand. No roentgenogram was obtained in his case, and his case was charted as a questionable one of radio-ulnar synostosis.

He belonged to a family of twelve children. Of these, the first (Fig. 5, II-2), male, born in New York City, 55 years before, was well developed and well formed, 5 feet and 11 inches (1.8 meters) tall and weighed 190 pounds (86.3 kg.). He was a heavy smoker. He enjoyed uniformly good health, and an examination was negative for skeletal defects. His wife also was devoid of skeletal defects, but suffered with diabetes and had cataracts on both eyes.

They have had six children. A boy (Fig. 5, III-1), born in 1887, a full-term baby of normal birth, excepting for an attack of diphtheria when a child had never been ill. He was a short stout man, well formed and without physical defect. The next three children died under 4 years of age. The eldest of these, a girl, who died at 4 years of pneumonia, was said to have been without physical defect. The next one, a full-term baby, died at the age of 15 months of bronchitis. The third died at 8 months of convulsions while teething. The next brother (Fig. 5, III-5), born in 1896, was tall and slender, well developed and well formed. His only son at 3 years seems well formed. The last member of the family (Fig. 5, III-7), born in 1900, was above average height, and weighed 185 pounds (84 kg). His right arm seemed to deviate slightly from the normal at the shoulder when he supinated his right hand. He professed no awkwardness in handling things. No roentgenogram was taken, and the case was charted as a questionable one of radio-ulnar synostosis.

The eldest sisters of the father were said to be normal, but were not seen.

The next pregnancy resulted in a miscarriage (Fig. 5, II-7). A brother, who was not seen, was the next born. The next, a brother (Fig. 5, II-10), was tall, well developed and well nourished, apparently normal in all respects. He was a fireman by occupation. His wife, a normal woman, had five children

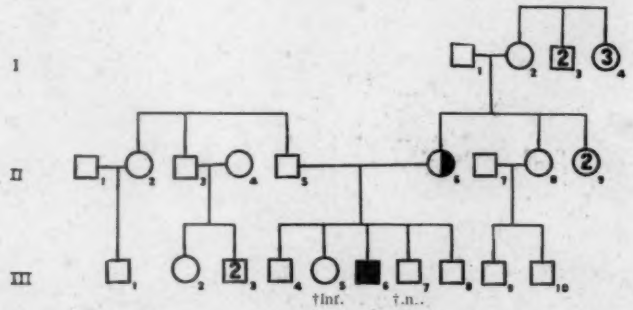

Fig. 12.—Pedigree chart of K. family: †inf, died in infancy.

Of these, the eldest (Fig. 5, III-10), a full-term baby of normal birth, has always been well except for measles, mumps and chickenpox. At the time of examination, he was 5 feet and 6 inches (1.7 meters) tall, weighed 140 pounds (63.6 kg.) and had no physical defects.

The next son (Fig. 5, III-11), born in 1904, was well developed, and well formed. He was 5 feet and 7 inches tall and weighed 135 pounds (61.3 kg.). He showed no skeletal defects.

The next son (Fig. 5, III-12), born in 1906, was a full-term baby of normal birth. At the age of 15 years, he was 5 feet and 5 inches (1.6 meters) tall, and weighed 115 pounds (52.2 kg.). As the left leg was shorter than the right, and much thinner, he wore a brace and used a crutch. When he was 9 months old, his mother noticed that his left leg was shorter than the right, so that the floor could be reached only with the tips of the toes. At 6 years, he was operated on at the Hospital for Ruptured and Crippled, the tendons being cut and stretched. The next year, the operation was repeated, and the leg considerably lengthened. He is in the second year of high school. Of the two remaining children, the first died of pneumonia at 2 months. The second, a 12 year old girl, was 4 feet and 10 inches (nearly 1.5 meters) tall, weighed 92 pounds (41.8 kg.) and appeared to be normal in all respects.

The next three members of the father's family died young, and there is no record of skeletal defect.

The next child, a daughter, (Fig. 5, II-16), born in 1880, a short stout woman, normal in all respects, and married to an apparently normal man, had a daughter (Fig. 5, III-15) born in 1908, who was tall, stout and well formed. When a young child, she had a "cyst or large exostosis" removed from the upper side of her left wrist and arm. This had not recurred.

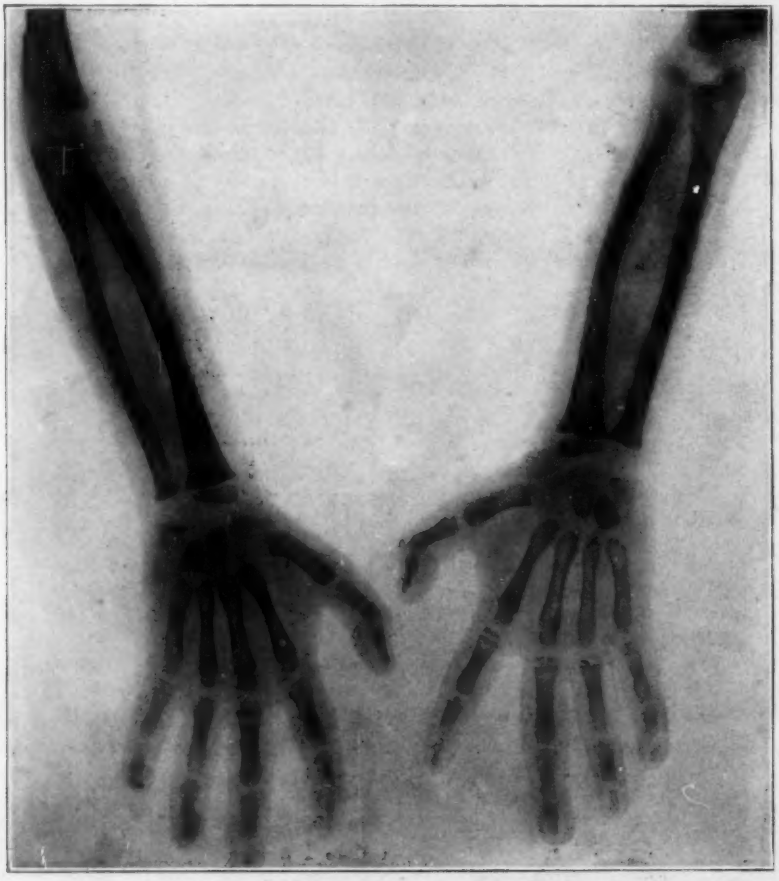

Fig. 13.—Arms, pronated, of I. K., May 18, 1921, at Hospital for Ruptured and Crippled.

The younger brother of the father (Fig. 5, II-20) was said to be normal, and so were his three children. The youngest brother (Fig. 5, II-22) lived in Ohio, and was 34 years old. It was stated that at the age of 20 years, he had a "cyst or exostosis" removed from his left wrist.

The father's father was said to have been free from bone defects. Both parents came from the South of Ireland. The sister of the father's father had a daughter (II-1) who was said to be a hunchback.

The father's mother, who died several years ago, was said to have been free from bone defects. Her parents were from the north of Ireland.

The mother of the propositus was a slender but well built woman of medium height, who appeared to be normal in all respects. She belonged to a large family, many of whom had children, and there was no history of bone defects on this side of the house.

Summary.—Unilateral synostosis in two brothers out of three, and also probably in their father was found. Possible radio-ulnar synostosis was present in a first cousin; and other bony defects (exostosis, etc.) existed in two first cousins of the propositus and the brother and the first cousin of the father.

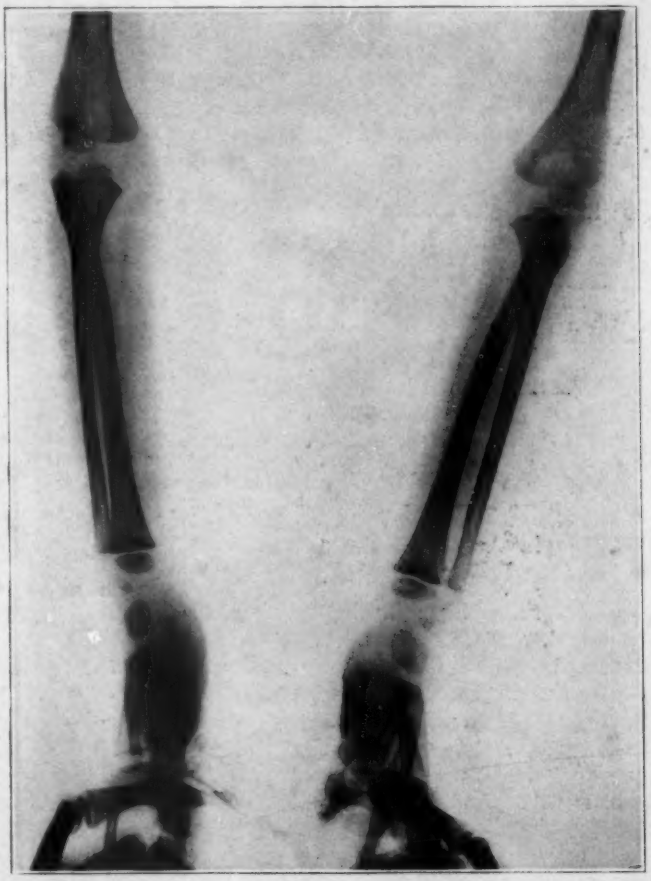

Fig. 14.—Arms, half pronated, of I. K., May 18, 1921.

3. *A. Family.*—The propositus (Fig. 6, V-7), a Russian Jew, born April 15, 1913, in New York City, was a full-term baby of normal birth and breast fed. Except for some stomach trouble, she had been healthy, and she was normal except for a unilateral (sinistral) radio-ulnar synostosis, which was first noticed when she was about 2 years old. This condition in no way interfered with her home or school duties. She could not supinate the hand, and so could not receive small articles in the left hand, but suffered little inconvenience therefrom since the left hand only was affected (Fig. 7). The hand was

usually held half way between pronation and supination (pronation at 135 degrees). Extention was limited to 135 degrees; flexion appears to be normal. An excellent roentgenogram of both arms is shown in Figure 8 and a tracing in Figure 9. The shaft of the left radius was bowed outward. The radial head, which was small, was bowed across and in front of proximal end of ulna. The ulna was also somewhat bowed away from the radius. The left hand could not be completely pronated. This is shown also in Figure 7. The left

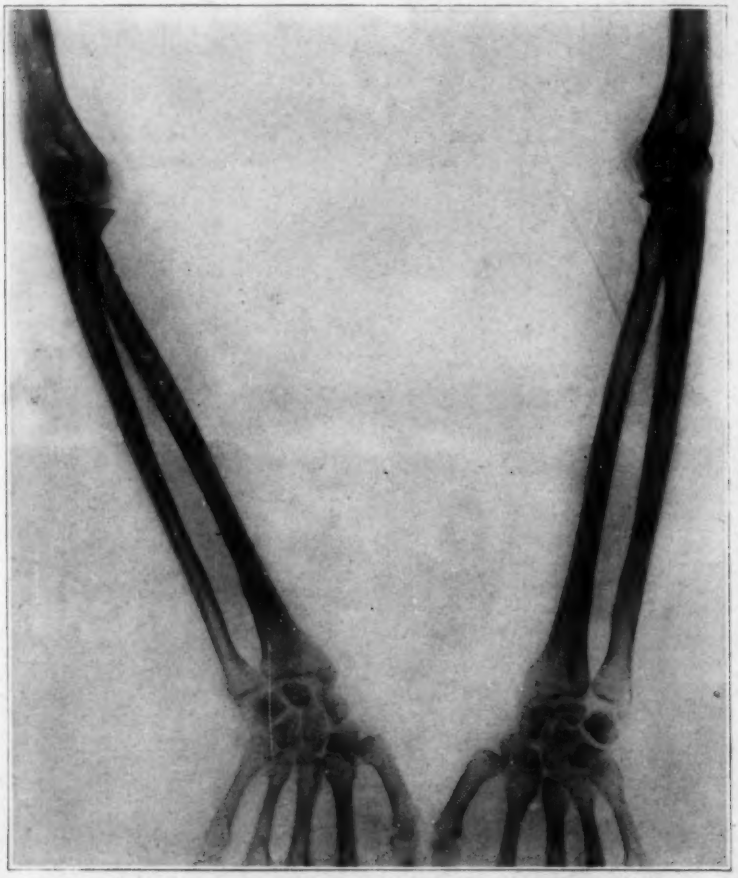

Fig. 15.—Arms, pronated, of Mrs. K., mother of M. K.

elbow is raised to assist in grasping the dish. The left arm was shorter than the right, the left ulna measuring less than 120 mm. and the right ulna about 132 mm. Both radius and ulna were slenderer on the right side than on the left. The left arm, with its bones, seemed to be quite normal roentgenographically and clinically. She had a younger brother and sister, both of whom appeared to be entirely normal.

The father of these children (Fig. 6, IV-10), except for stomach trouble, had always been healthy, and appeared normal in all respects. The third finger of his right hand appeared to be clubbed, but this he maintained to be

due to a deep cut which he experienced when a boy. He had five siblings, of whom several were seen by Miss Nelson, and none of whom had radio-ulnar synostosis. Some of them were rather short in stature, a racial trait.

The mother of the propositus (Fig. 6, IV-11), born in Minsk, Russia, in 1889, appeared to be entirely normal. The only other members of her immediate family died young in Russia. Her mother (Fig. 6, III-2) also died in Russia of appendicitis at the age of 30 years. She was said to be normal in respect to radio-ulnar synostosis as was also her husband.

A brother of the mother's mother (Fig. 6, III-8), who came to the United States in 1888, appeared to be normal in all respects. His wife (Fig. 6, III-7) died of paralysis. Her mother's brother had a son whose wife (Fig. 6, III-9) had two brothers who stutter, and who in turn have stuttering children. It is probable that from the germ plasm of the woman (Fig. 6, III-7) there are found defects of lisping in two of her three children, and of stuttering in two of her grandchildren. One of the stuttering children (Fig. 6, IV-16) is tall (71 inches or 1.8 meters) and corpulent (260 pounds or 11.8 kg.). He was normal (no radio-ulnar synostosis), but had a slight lisp. His wife was a tall, very fleshy woman, who appeared to be normal.

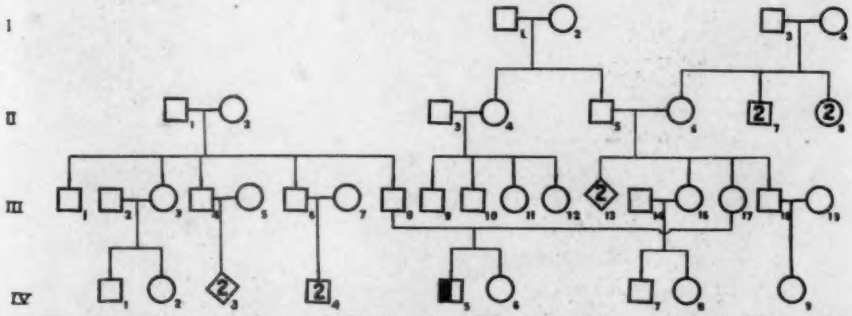

Fig. 16.—Pedigree chart of T. family. Figures with symbols indicate the number of other individuals of the given sex.

Their first two sons are stutterers. The third child (Fig. 6, V-12), a daughter born in 1913, was a full-term baby of normal birth. At 9 months of age, it was noticed that her right arm was crooked and stiff, and she was treated at two hospitals. The right hand was now held half way between pronation and supination, and could not be fully supinated. Extension was slightly limited and she could not reach up fully, or turn her hand to comb her hair. She was awkward in using her hand, and experienced considerable pain in the shoulder and elbow. At attempt was made to secure a roentgenogram in this case, but it was not possible to secure cooperation. Although the diagnosis of infantile paralysis had been made, the identity of the symptoms to those of radio-ulnar synostosis, such as is shown in her second cousin (Fig. 6, V-7), seemed to warrant entering her case in the chart as probably radio-ulnar synostosis.

A tall slender man (Fig. 6, IV-18) appeared to be normal in all respects except for a slight lisp. He had a son (Fig. 6, V-13) who was negative for radio-ulnar synostosis. He was tall and slender for his age. The right middle finger curved slightly to the radial side. He had a sister who was normal except for a slight amount of strabismus. Other cousins in the family were entirely normal.

Comment.—The pedigree is imperfect, as many members of the family live in Russia. It contains one certain and one doubtful case of unilateral radio-ulnar synostosis (in female second cousins). The father of one had a clubbed finger (which, it is alleged was due to an accident in boyhood). A first cousin of the other had a curved finger. There were many cases of speech defect in the family.

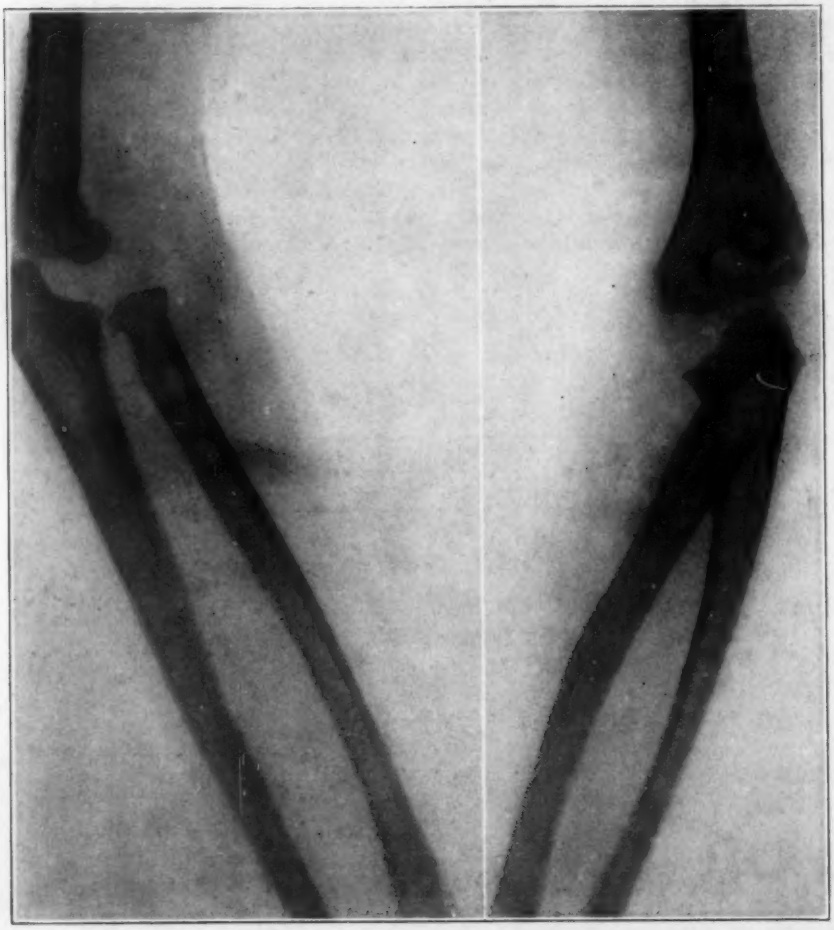

Fig. 17.—Arms of S. T., showing sinistral synostosis, Feb. 16, 1921 (Hospital for Ruptured and Crippled).

4. *L. Family.*—This family, of Jewish extraction, came to this country from Austria and Roumania about 20 years previously. The members of the family were of low mental capacity and were recipients of financial aid.

The propositus (Fig. 10, III-7), born in New York City, in December, 1916, was an undernourished, bashful, stubborn, quarrelsome child, who was constantly teasing other children. Both of her arms were crooked, and she had

a bilateral radio-ulnar synostosis with no power of supination. This was first noticed when she was 2½ years old. Flexion was normal, and extension was limited to 145 degrees in the left arm and to 155 degrees in the right. She

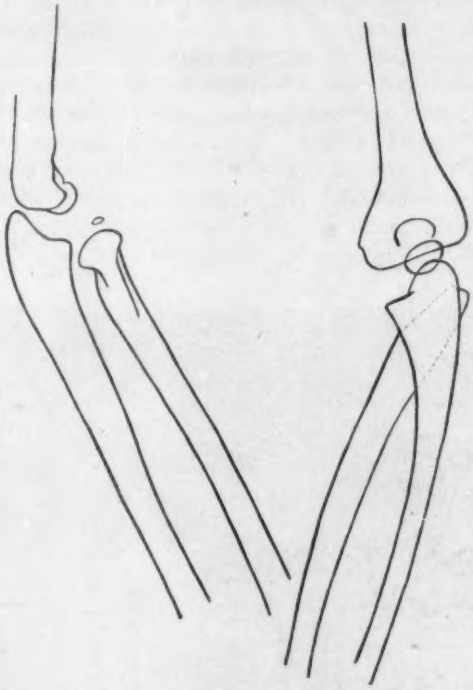

Fig. 18.—Outline of roentgenogram of S. T., boy, aged 9 years. At the left, is a nearly fronto-anterior view. The capitellum is large and closely applied to the distal end of the humerus. The right side is nearly perpendicular to the sagittal plane. The center for the radius head is already well developed. The head and neck of the radius are normal without synostosis with ulna.

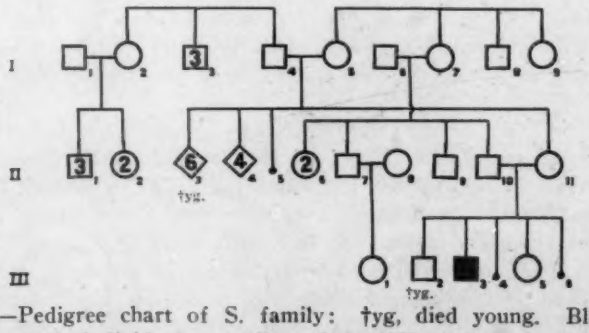

Fig. 19.—Pedigree chart of S. family: †yg, died young. Black symbols indicate synostotic individuals; small symbols (III 4, 6), one miscarriage, one early death.

could not turn up either palm to receive articles handed to her. Pronation, right and left, was fixed at 110 degrees.

There were seven other children in her family. Of these, Nos. 2, 3, 5 and 6 were seen by Miss Nelson and Nos. 4, 5 and 8 by Miss Katherine Belzer. No. 3,

a boy, was feeble minded, flatfooted, knockkneed and very anemic. It is possible that he had a slight bilateral radio-ulnar synostosis, but it was not definite enough to be entered on the chart. No. 4 was also feeble minded, with an intelligence quotient of 0.49. Like his brother, No. 3, he had chorea; he could supinate perfectly and pronate to about 170 degrees, and he could be induced to flex the left forearm to 60 degrees, the right to 75 degrees only. His arms and legs were of normal length (relative span 1.032; relative sitting height, 0.544). Nos. 2, 5 and 6 were certainly normal in skeletal development; though No. 5 (J.) had a rather short span. No. 8, born in 1919, at 19 months neither walked nor talked. At 3 years and 8 months, both arms could be supinated and pronated, but with difficulty. They could be flexed to 50 degrees. His arms and legs were of normal proportion (relative span 1.017; relative sitting height, 0.549). This difficulty in arm rotation in a young child (observed

Fig. 20.—Left: C. S., showing method of measuring the angle of pronation and maximum pronation when elbows are held close to body. Right: Increase in angle of pronation when elbows are elevated away from body.

independently by two investigators) strongly suggests a certain (though slight) degree of synostosis. No. 1 of this family was not seen. He was said to be normal in skeletal development. The father, a factory operator in New York, was said to be negative for radio-ulnar synostosis, as were also his four brothers and one sister, who were still living in Austria.

The mother (Fig. 10, II-5), born in Roumania in 1880, and of low grade mentality, showed a radio-ulnar synostosis in both arms, apparent from birth, and the lower arm was much bowed. She could not supinate the hands nor receive small articles in either palm. She had difficulty in using her eating utensils at the table. Flexion was normal. Extension was limited in the right arm to 135 degrees and in the left to 150 degrees. She was very short, and had a large goiter which, she stated, caused no discomfort. Examination of the roentgenogram shown in Figure 11 demonstrates that the radius did

not articulate with the distal end of the humerus, but was joined to the ulna at the region of the attachment of the biceps and above. Though the union was apparently complete, the outline of the upper end of the radius could be traced on both arms. No radial heads were formed on either side.

5. *K. Family.*—The propositus (Fig. 12, III-6), born in 1917, in New York City, was a full-term baby, weighing 8 pounds (3,628 gm.). The birth was a breech presentation, with instrumental delivery. The boy talked at 2 years and walked at 3 years. He suffered from pneumonia when 18 months old, and from convulsions when teething. While he was still a very young infant, his mother noticed that he could not supinate his hands. At the time of examination (1921), they were both held in a position of pronation (right, 135 degrees; left, 140 degrees), and he could not turn the palms up to receive small articles.

The roentgenogram (Fig. 13) shows the hands pronated. The proximal head of the left radius was seen to lie far on the flexor side of the ulna, for in the roentgenogram the hinge-axis of the distal end of the humerus lies perpendicular to the photographic plate. On the right side, the head of the

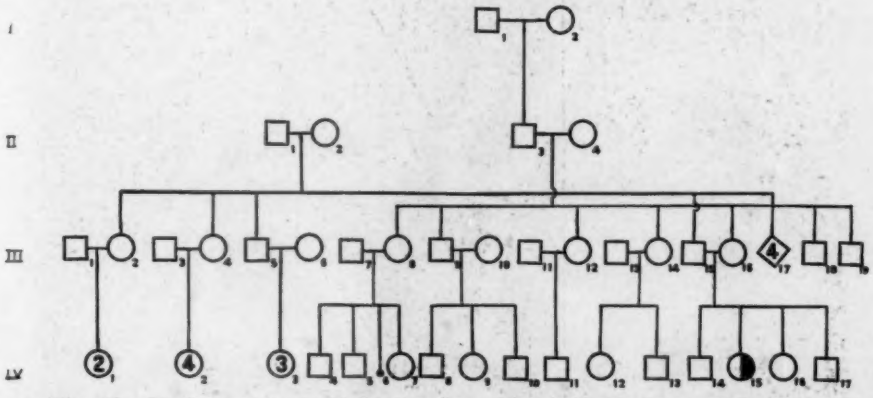

Fig. 21.—Pedigree chart of St. family. The half black symbols indicate unilateral synostosis. Figures in symbols indicate number of individuals in a given sex.

radius was more deformed and was closely applied to the ulna. When the hands were at 90 degrees (Fig. 14), the hinge joint of the humerus was seen more nearly *en face,* owing to the fact that the elbow could be drawn in toward the ribs. On the left side, the radius crossed the ulna proximally, the head of the radius overlying that of the ulna. On the right side, the two bones of the forearm crossed farther distally, and the imperfectly formed head of the radius had been carried, by the rotation of the proximal end of the ulna, toward the outside of the arm. Now the head of the ulna was bound to the distal end of the humerus, and the latter could not be further rotated. The head of the radius was probably fused with that of the ulna; hence, the distal end of the radius, which controls the movement of the hand, could not rotate further toward a supinate position. Extension and flexion appeared to be normal. The boy was pigeontoed and had a peculiar gait. He found it difficult to run or walk fast without falling down. He was irritable, and his appetite was insatiable. He drooled constantly, and probably was below normal mentally.

He had four four siblings. One (Fig. 12, III-4), born 1914, a full term baby of normal birth, weighing 7½ pounds (3,402 gm.), bottle fed, walked and talked at 16½ months. Both index fingers curved toward the ulnar side of the hand, but he showed no other skeletal abnormalities. Nos. 5 and 7 died in infancy, and No. 8, 1 year old, was not seen by the investigator.

The mother (Fig. 12, II-6), aged 31, was 4 feet and 8½ inches (1.4 meters) he is in an institution for the tuberculous. He, his two siblings, and their six children were said to be free from skeletal defects.

The mother (Fig. 12, II-6), aged 31, was 4 feet and 8½ inches (1.4 meters) tall and plump. She could not fully supinate the right hand, and an attempt

Fig. 22.—Lateral view of right arm of Miss G., March 26, 1921, showing extensive fusion of radius and ulna at proximal ends of the bones.

to do so caused considerable pain (pronation from 90 to 160 degrees); but she had learned to adjust herself to her work as an operator in a rug factory. She suffered greatly from flat feet. She appeared to be subnormal in intelligence.

The roentgenogram (Fig. 15) shows the mother's hands and forearm in pronate position. In order to pronate the left, she had to throw the elbow outward. Her condition was much more nearly normal than her son's. On

both the right and the left side, the proximal head of the radius was fully formed, and lay nearly in the same plane that contained the head of the ulna and passed through the hinge line. The roentgenogram at 90 degrees' pronation showed the radius and ulna in the same plane with the wrist. The head of the radius was in contact with the capitulum. As Dr. Taylor stated, the roentgenograms "are inconclusive as to synostosis."

A sister (Fig. 12, II-8), aged 28 years, was shorter and was very small boned and slender. Both of her children were born by cesarean section.

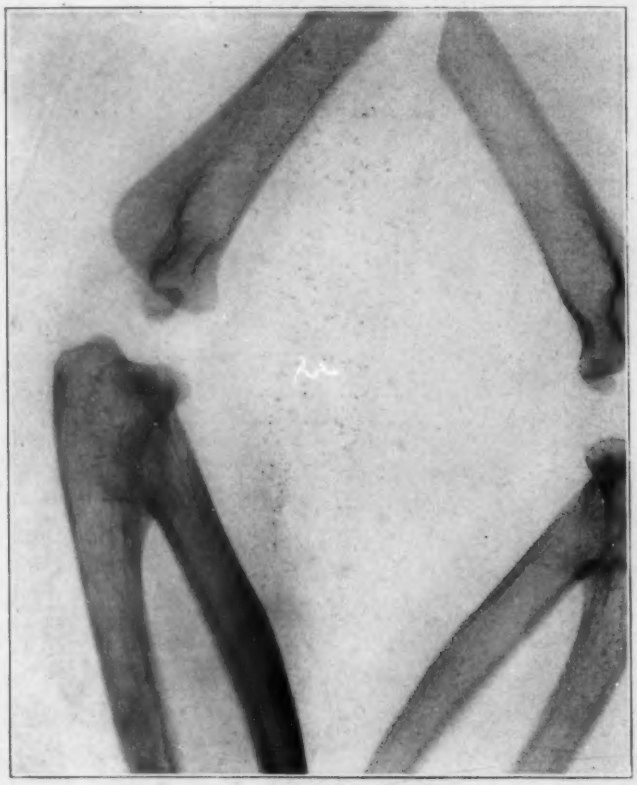

Fig. 23.—Elbows of B. P., taken April 7, 1920, showing complete synostosis of both arms.

Another sister (Fig. 12, II), aged 24, who lived in Cleveland, was not seen. She was tall and stout; married, but had no children, probably because of the sterility of her husband.

Another sister (Fig. 12, II-8), aged 22, who was not seen by the investigator, was said to be tall and slim. She had two daughters, and she and they were said to be negative for synostosis. The mother's father was a pedlar, tall and slim, and, like his three brothers and one sister, negative for radio-ulnar synostosis.

The mother's mother lived in Newark, N. J. She was characterized by short stature. Her five brothers and sisters and their numerous offspring were said to be negative for radio-ulnar synostosis.

6. *T. Family.*—The propositus (Fig. 16, IV-5), a boy, born in 1912, a full-term baby of normal birth, weighing at birth only 3 pounds (1,360 gm.) early showed a unilateral radio-ulnar synostosis of the left arm. The second and third toes of the feet were united by a web. Until he was weaned, he was a healthy child, but he had since suffered from measles, diphtheria and enlarged glands of the neck. At the age of 9 years, he was ill-nourished and undersized, and

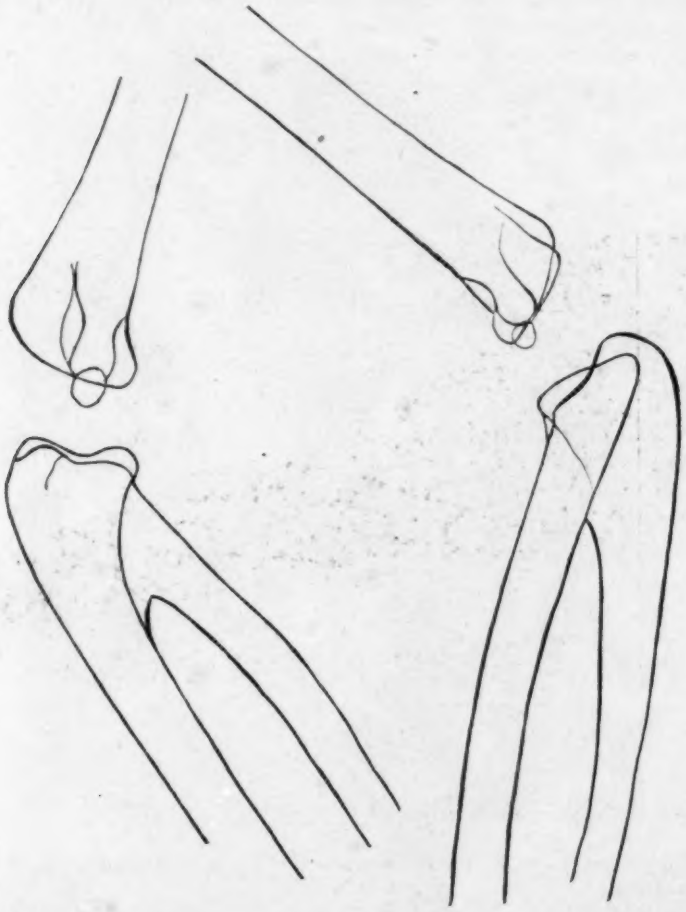

Fig. 24.—Outline of roentgenogram of the elbow of a 15-year-old boy (P. family), showing bilateral radio-ulnar synostosis. On both arms, the eminentia capitata is visible at the distal end of the humerus.

had very small eyes, large protruding ears, irregular teeth and an unsymmetrical head. He was two years retarded in school. He could not receive small articles in the left palm, and held the hand half way between pronation and supination (left pronation limited to 170 degrees). Extension was normal. Flexion was limited in the left elbow to 165 degrees. In his work and play, he was able to make the proper adjustments.

The roentgenogram (Figs. 17 and 18) shows apparently complete fusion of the proximal ends of the radius and ulna on the left side. There was a modified radial head. The shaft of the left radius was bowed outward. On the right side, there was no fusion, but the head of the radius was not of normal form. It was rounded on top and carried a hook or spur on the side next to the ulna.

He had one sister, aged 8 years, who showed no skeletal deformities. The father, born in Austria in 1885, was a manufacturer in New Jersey. It was stated that he and his four siblings and their children, none of whom were seen by the investigator, were normal in skeletal development.

The mother (Fig. 16, III-1) was apparently normal in skeletal development. She had one surviving sibling who lived in Austria and was said to be normal. All uncles and aunts of the mother, and their children, were stated to be negative in respect to synostosis. The daughters of the mother's paternal aunt (Fig. 16, III-12) was said to be a cripple.

Fig. 25.—Right arm of M. Pa., at 9 years, before the operation for synostosis performed by Dr. D. D. Ashley at Waterbury, Conn., in 1916.

7. *S. Family.*—The propositus (Fig. 19, III-3), born in 1907, normally at full-term, weighing 8 pounds (3,628 gm.),[2] during infancy was marasmic, and cried a great deal. At 2 years, he had diphtheric croup, and at 3 years, scarlet fever, which left him deaf in the right ear. When he was past 2 years of age, his mother first noticed that he always held his palms down, and she found he could not turn them up, and that she could not turn them up for him. As he grew older, it was noticed that he was very awkward in handling table utensils and could not turn his palms up to receive change; and at school, he found it difficult to hold his book up for reading. He was, however, able to adjust himself to ordinary activities, though his hands were held half way between pronation and supination, and extension was slightly limited (pronation of right hand, 120 degrees; left, 130 degrees; extension, 180 degrees; Fig 20). The little finger of his left hand was very crooked. He was very flatfooted, like

2. Referred by Orthopedic Hospital.

his mother's mother. The record at the orthopedic hospital where he was examined Feb. 5, 1921, states:

"General condition good. Incisors separated; serrated edges. General glandular adenopathy. Spine straight and flexible. *Uppers:* left normal;[3] *right,* patient holds forearm in pronation; unable to supinate; normal relation of condyles and olecranon; apparently some bony abnormality at upper end of radius and ulna. No history of injury. *Lowers:* Hips and knees negative. *Feet:* right, dorsiflextion 100 degrees. Anterior arch flat; scaphoid tubercle prominent and low down; base of fifth metatarsal prominent. All muscles seem rather spastic. Toes not freely flexible. *Left:* dorsiflextion 105 degrees; points of tenderness over scaphoid tubercle; anterior arch flat; muscle power normal; patient stands with feet everted and pronated; walks with typical gait of muscle bound feet. "February 9, operation for lengthening of both tendo-Achilles."

There were four other pregnancies, including a miscarriage. A boy, who died at 5 years of scarlet fever, was said to have no skeletal defects. A girl of 10 years, was large and well, but had flat feet and very large ankles, which were bowed.

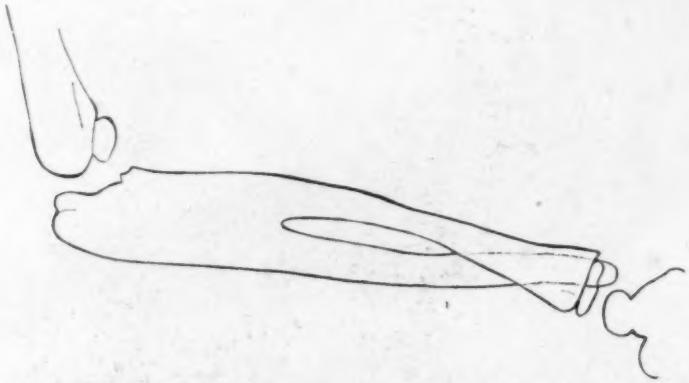

Fig. 26.—Outline of roentgenogram, showing radio-ulnar synostosis of the right arm of M. Pa., a boy, aged 15 years. The eminentia capitata is seen closely applied to the distal end of the humerous. The olecranon is fully ossified and in close contact with the distal end of the ulna. The extent of the synostosis is extraordinary.

The father was said to have been normal, as were also his four siblings. The father's mother, who was the sister of the mother's mother, was also without skeletal defect.

The mother (Fig. 19, II-11), born in 1882, a full-term baby of normal birth, was marasmic as an infant, and had all of the children's diseases in childhood. She had four surviving siblings, none of whom ever left Germany. The mother's father, who lived in Germany, was said to be negative for radio-ulnar synostosis, and the same was said to be true for his three brothers. His sister (Fig. 19, I-2), who was without skeletal defect, had five children also negative, including a son who had seven children. She was below the average in mental and physical development, but showed no trace of radio-ulnar synostosis.

---

3. These findings are not in accord with measurements given above and the evidence of the photograph (Fig. 20).

8. *St. Family.*—The propositus (Fig. 21, IV-15), from a family of Hungarian origin, with some bone defects on the maternal side, was born in New York City, in November, 1908. She was a full-term baby of normal birth, weighing 7½ pounds (3,402 gm.) and had never been ill. She was short, slender and well formed except for a right radio-ulnar synostosis, which was first noticed when she was 2 years of age. She could handle table utensils with ease. Her right hand was held in extreme pronation. Flexion seemed to be normal, but she could not raise her arm above her head. Of her siblings, one died at birth; a sister, slightly over a year old, was well formed; and a brother, 1 month old, seemed to be free from bone defects.

The father was a man of medium height without bone defects; and it is stated that his eight siblings, most of whom lived in Hungary, were without bone defects, also.

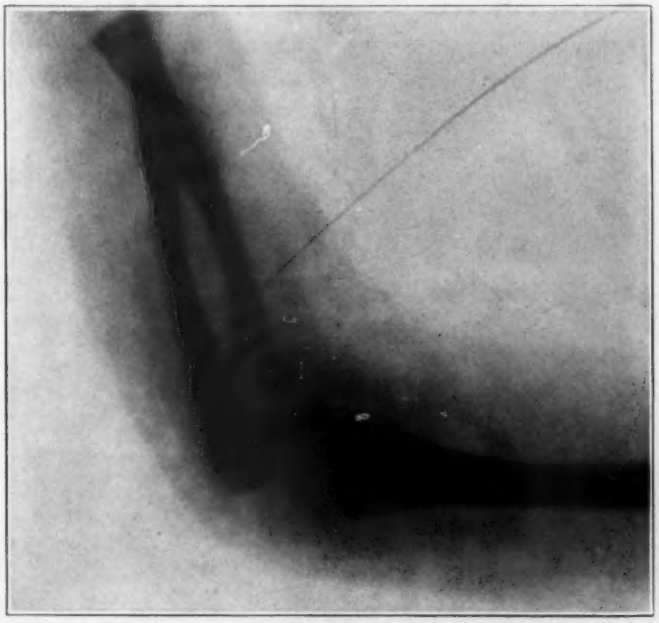

Fig. 27.—Left arm of Kr., 1 month-old infant, showing synostosis (Hospital for Ruptured and Crippled, April 15, 1921).

The mother (Fig. 21, III-16) was short, stout and well formed, and without bony defect. She had a sister (Fig. 21, III-8) who was very poorly nourished, and had a marked kyphosis. She had developed an exophthalmic goiter, and was very irritable and nervous. She had a son (Fig. 21, IV-8), born in 1893, at full-term, weighing 8 pounds (3,628 gm.). He had flat feet. His sister, aged 11 years, was slender, and had a kyphosis like that of her mother. The remaining siblings of the mother were said to be negative for bone defects.

The mother's father was said to be free from bone defects, and the mother's mother, who was short and stout, had no radio-ulnar synostosis.

9. *G. Family.*—The propositus, a woman born in 1897, was tall, slender, vivacious and handsome. At the time of observation (1921), she was with a vaudeville company. Her birth and childhood were normal, but it was early

noticed that she had a slight dextral radio-ulnar synostosis, making it impossible for her to turn up her palm to receive small articles handed to her, and awkward for her to handle utensils at the table (pronation fixed at 135 degrees). In carrying heavy articles, she experienced some pain in the middle arm. Flexion and extension were practically normal. A brother and sister appeared to have no trace of skeletal abnormality. The propositus had two half siblings living in England, who were said to be normal. Both served in the late war. The father and mother were both actors. It is stated that they and their siblings were without skeletal defect.

The roentgenogram of the forearm of the propositus (Fig. 22) revealed a complete union (cancellous fusion) of the radius and ulna at the upper end. The radius articulated with the outer condyle of the humerus, and the fusion

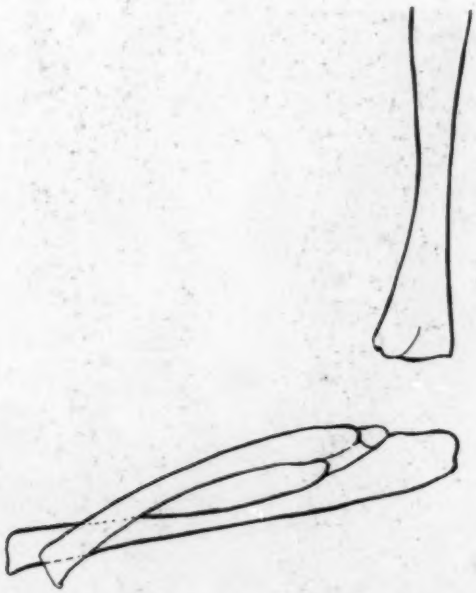

Fig. 28.—Outline of roentgenogram (Fig. 27), showing sinistral radio-ulnar synostosis in a baby boy, aged about 6 weeks. Lateral view of a partly flexed arm is shown. The radius is strongly curved and united to flexure or front surface of ulna. The union is still largely cartilaginous.

of the two bones of the forearm was complete to below the level of the radial tubercle. The head of the radius appeared not to lap over the upper end of the ulna, but to engage the capitellum of the humerus. If this was correct, the inability to supinate was due to the bowing and torsion of the radius.

10. *P. Family.*—The propositus, a boy, born in March, 1913, was a normal healthy child, except for bilateral radio-ulnar synostosis, which was noted at birth. Neither hand could be fully supinated, nor could he receive small articles in either palm (right fixed pronation, 135 degrees; left, 150 degrees). The left arm was operated on by Dr. Tayor, April 20, 1920, with the result that a slight degree of supination was possible in that hand. The operation consisted of removing 1.5 cm. of the radial shaft adjacent to the synostosis, as suggested

by Lever. The arm was in a plaster-of-Paris splint about four weeks. The radius was reunited. Flexion was normal. Extension was normal in the left arm and limited to 170 degrees in the right.

The roentgenogram (Fig. 23) and Figure 24 show the arms of the 7-year-old child extended at pronation. The radius was bowed to an abnormal degree.

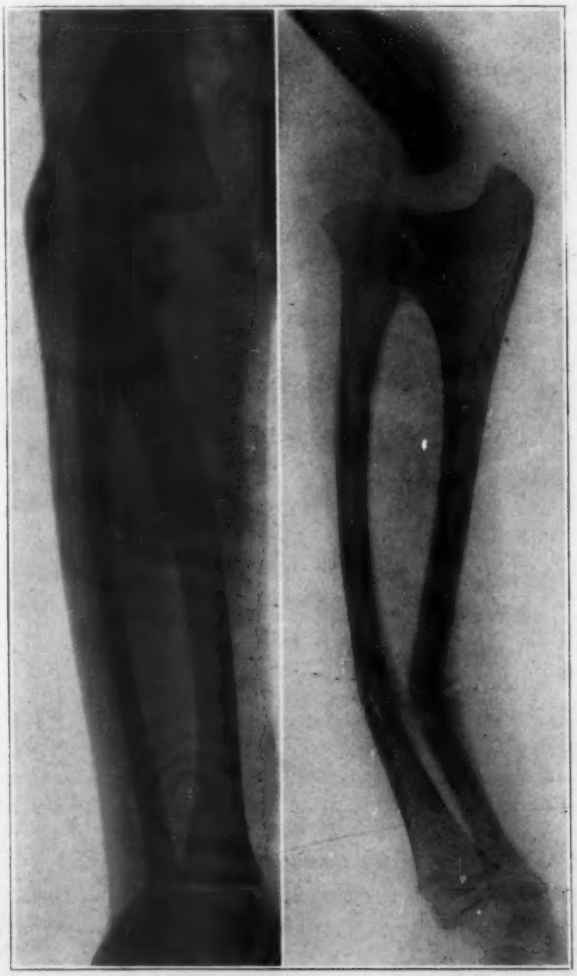

Fig. 29.—Left: Right forearm of D. B., showing slight extent of synostosis, recent fracture of forearm and loosening of the surface of fusion (Drs. Wollcott and Taylor, Oct. 8, 1921). Right: Left forearm of D. B., showing synostosis, (Oct. 8, 1921).

The union of the bones of the forearm with the humerus was still very immature on each side. The fusion of the proximal end of radius and ulna was complete in both arms.

Two sisters of the propositus, 5 and 6 years old, respectively, showed no synostosis. The father, a Russian Pole, was not seen. His five siblings, as well as their parents, were said to be negative for radio-ulnar synostosis. His mother was said to have died in childbirth at the age of 39 years.

The mother, also a Russian Jew, showed no radio-ulnar synostosis. She has four siblings who were not seen. They and their children were said to be free from this defect. The mother's mother and mother's father were also said to be free.

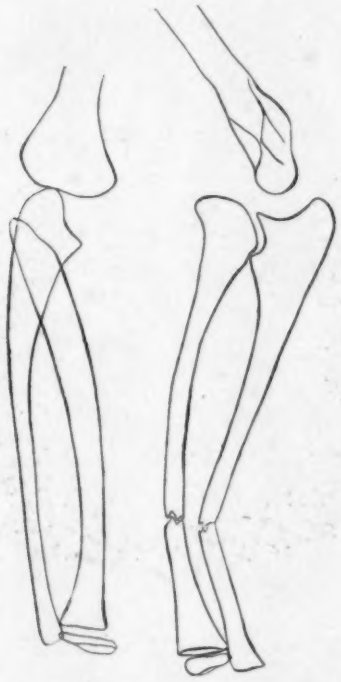

Fig. 30.—Outline of roentgenogram, showing an accidental fracture of the right forearm, detaching the radial head from the ulna. On the right, is a nearly fronto-anterior view, showing the radial head lying above on the flexure aspect of the ulna in the position of the coronoid process of the ulna.

Comment.—While heredity was apparently not a factor in this case, it must be noted that only the two siblings and the mother of the propositus were seen. For the rest of the family, we have only noncritical statements.

11. *Pa. Family.*—The propositus,[4] a boy, born in 1907, was a full-term baby weighing 8 pounds (3,628 gm.), delivered instrumentally. Except for children's diseases, he has been quite healthy, and was said to be normal physically, except for a unilateral (dextral) radio-ulnar synostosis, which his mother first noticed, when he was 3 years old, through his inability to turn up his right

4. From the clinic of Dr. Dexter D. Ashley of 346 Lexington Ave., New York, and Waterbury (Conn.) Hospital.

palm to receive small articles. The boy was operated on by Dr. Ashley, in 1916, but no reports of the operation are available.

The two other pregnancies of his mother were: a miscarriage at four months, and a stillbirth at seven months.

About the father, nothing was known except that he was alcoholic. It was stated that he did not show radio-ulnar synostosis.

The mother, who was born in Ireland, in 1881, was alcoholic, and talked in an erratic, irritable, rambling, emotional, abusive fashion. She had no radio-ulnar synostosis. She had ten siblings, all of whom were born in Ireland, and none of whom were seen, although all were said to be free from the condition.

The roentgenogram (Fig. 25), for which we are indebted to Dr. Dexter B. Ashley, shows an extensive union of the radius and ulna over a distance of about 6 cm., or 3 cm. distal to the bicipital tuberosity. This is far more

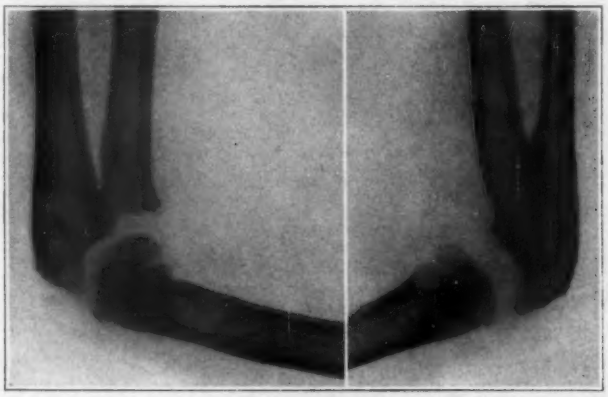

Fig. 31.—Arms of I. L., showing sinistral radio-ulnar synostosis.

extensive a line of fusion than is usually found. The radius was much bent. It is probable that the interosseus membrane was calcified (compare also Figure 26).

Comment.—This case seems to resemble that of the propositus in the G. family. Though the roentgenogram does not show details, it is probable, from the appearance of the proximal end of the bones of the forearm, that they are fused side by side, and that the membranes and ligaments lying between them are calcified.

12. *Ka. Family.*—The propositus (L. K.), a Russian Jew, a woman born in Russia in 1900, came to the United States in 1920. She was born at term (normal birth), and was now strong and healthy, of medium stature and fleshy build. At 2 years of age, she showed a defective handling of her arm. A short time after she arrived in this country, she visited the New York Orthopedic Hospital Clinic concerning her arm. The case was diagnosed as radio-ulnar synostosis. She could pronate but not supinate her left hand, but her right was normal. Her left arm had a normal range of flexion and extension.

She was employed in a skirt factory, and was in no way incapacitated by her defect. She was of apparently normal intelligence, and was attending night school in order to learn the English language.

She had six siblings, three of whom were without obvious skeletal defect. Such defects were denied for all. Only one was of short stature.

The father was short and slender, and apparently not affected with synostosis. All of his siblings were said to be negative. The mother was of medium height, and inclined to be stout. She had a goiter, but no bone defect was admitted.

Comment.—Only the parents and four children were seen. On account of the fact that most of the family were still in Russia, little study could be made of their heredity.

13. *Kr. Family.*—The propositus, an Austrian Jewish boy, born at Gouveneur Hospital in March, 1921, at full-term and of normal birth, at the time of examination (April 15, 1921) was breast and bottle fed. At birth, his aunt

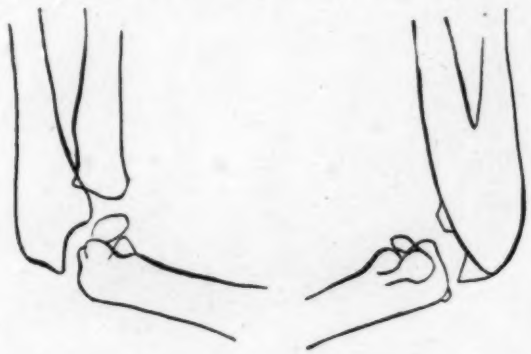

Fig. 32.—Outline of roentgenogram (Fig. 31) of the elbows of a boy of 11 years, showing radio-ulnar synostosis on the left side. In the view of the left elbow perpendicular to the sagittal plane, the radius appears fused to the proximal end of the ulna on the lateral aspect since the coronoid process appears above the position of the neck of the radius.

noticed that both arms were flexed, and that the fingers of both hands were kept extended. The hands were very blue, seemed stiff and could not be extended fully. A later examination, by roentgenogram, at the Hospital for Ruptured and Crippled, by Dr. Taylor, showed that the child had a sinistral radio-ulnar synostosis, with limited extension (elbow extension 150 degrees) and lack of ability to supinate (pronation from 20 to 160 degrees). The radius and ulna were fused from the proximal end to beyond the tubercle of the radius. The fingers of the hand were very long, a family trait. The right forearm showed no fusion but was not normal (extension, 160 degrees). The roentgenogram (Fig. 27) and Figure 28 show an intimate union of the radius and ulna at their proximal ends; but it is not certain that the radius overlaps the ulna. Two brothers, 4 and 6 years, respectively, showed no skeletal defects.

The father, who was not seen by the field worker, was said to be free from skeletal defects. He had very long and slender fingers. By another wife, he

had two daughters, of whom the eldest developed normally. The second, up to the age of 16 years, was much undersized, but at the onset of menstruation at that age, she grew rapidly and was said now to be of average stature. The father had seven siblings, mostly in Austria. All were said to be free from synostosis.

The mother appeared to be normal in skeletal development. Two of her sisters, who are in New York, also appeared to be quite normal. The mother's father was said to have been so short that he was exempted from military service. He had a number of sons and daughters, for none of whom was synostosis admitted. Of the mother's people also, entire freedom from the defect was alleged. A number of them were seen and questioned, and no case was detected among them.

14. *D. B.*—This case was of special interest because of peculiar incidents. When the boy was 1½ years of age, his mother noticed that he held spoon and fork in a peculiar manner. Investigation revealed a bilateral synostosis, permitting of no rotation but of free flexion. At 6 years, he fell and broke the bones of the right forearm and at the same time detached the radial head from the ulna, so that a slight amount of rotation was possible. The roentgenogram (Fig. 29), made about this time (Oct. 8, 1921), shows that the head of right radius was well developed. It lay in front of ulna and did not engage the distal end of the humerus. The head of the ulna showed a somewhat abnormal growth to unite with the radius. Despite the break, the forearm was fixed at 90 degrees. The right elbow could be extended to 175 degrees. The left radial head was not well developed and lay in front of the head of the ulna. The radius and ulna were both bowed. Rotation was fixed at 135 degrees, extension to 190 degrees. (Compare also Figure 30.)

15. *I. L.*—A boy of 11 years showed radio-ulnar synostosis on the left side. This side was fixed in pronation, with extension to 170 degrees. The right arm was apparently normal. The roentgenogram (reduced) Fig. 31 and Fig. 32) shows that, on the left side, the radius lies alongside the ulna, apparently without any distinct head. The fusion seemed to be complete.

Comment.—This case resembles closely that illustrated by Figure 33, though the union is not quite so extensive.

III. TYPES OF RADIO-ULNAR SYNOSTOSIS

The osteogenic defect known as radio-ulnar synostosis is not a simple, uniform one. On the contrary, it varies greatly in its details. How variable it is may be inferred from a table published by Madrange (1914). Before the era of roentgen rays, the full interpretation of conditions found in the living subject was difficult. Now it can be made with assurance. Some of the differences are due to the age of the patient. This fact is well brought out in Figure 33, traced from Baisch (1913). In the roentgenogram (*b*) taken at from 3 to 4 years, the outline of the proximal end of the radius can be traced, overlying the ulna. At 11 years (*a*), the outline can no longer be traced; and the fusion appears to be complete. The progress of fusion with advancing age is clearly seen in certain deer, in which the radius and ulna are distinct

in young animals but become fused in old ones; and this is, apparently, as truly a physiologic process as the union of the human skull bones in later life.

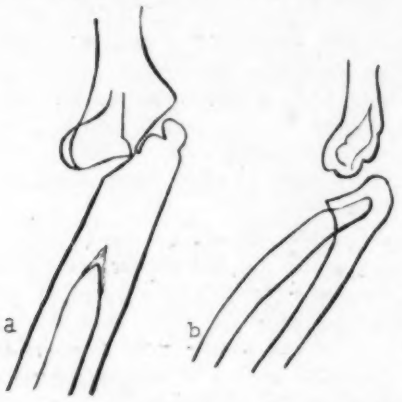

Fig. 33.—*a*, outline of roentgenogram of forearm and elbow of a girl, aged 11; *b*, outline of roentgenogram taken seven or eight years earlier. (From Baisch, 1913.)

Fig. 34.—Outline of roentgenogram in a case of synostosis in a man, aged 30; view perpendicular to the sagittal plane. The dotted line shows the position and form of the normal radius. (From Roskoschny, 1905.)

In order to illustrate the different types of radio-ulnar synostosis, a series of tracings of some of the roentgenograms that have been published is herewith reproduced in Figures 34 to 49.

In the least modified cases, the radius was merely strongly curved. Such a strong curvature, with synostosis, is seen in Figure 8, and to a less degree in Figure 13 (left), in which the radius head is distinct. In Figure 15, the radius is slightly bowed, especially on the left, and there is inability to supinate, though the head of the radius seems to be well formed.

The next type of radio-ulnar synostosis, and the commonest, may be called the headless type. This is well illustrated in Figures 3, 13

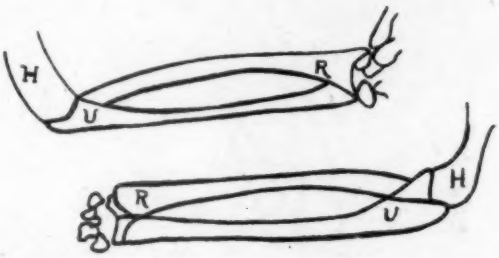

Fig. 35.—Outline of roentgenogram of both forearms of a woman, aged 42 (mother of the girl in Figure 36), showing radio-ulnar synostosis; *R*, radius, *U*, ulna. (From Feidt, W. W.: Surg., Gynec. & Obst. **24**:700, 1907.)

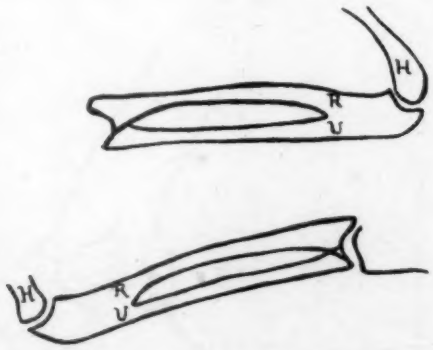

Fig. 36.—Outline of roentgenogram of both forearms of a girl, aged 15, daughter of the woman of whom the roentgenogram in Figure 35 was made. Extensive synostosis is indicated. (From W. W. Feidt, 1917).

(right); 17, 23, 25 and 27 (left); also in text figures 18, 34, 35, 37, 33 *a*, *b*, 41, 42, 45 and 46. Of these tracings, Figure 34 is instructive because the author has marked on it the outline of a radius of normal shape and in normal position. Figures 35 and 36 are interesting as roentgenograms of right and left arms of mother and child, which show an apparently somewhat more intimate fusion of bones in the younger person. In Figure 37, from a 7-year-old girl, the upper end of the radius, without a well-molded head, is seen lying sidewise against the

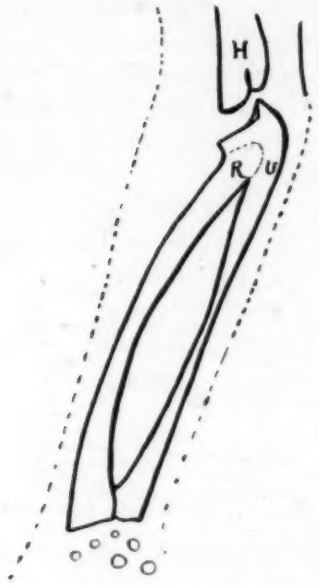

Fig. 37.—Outline of roentgenogram of the bones of the partly pronated forearm in a 7-year-old child. (From Ahreiner, 1909.)

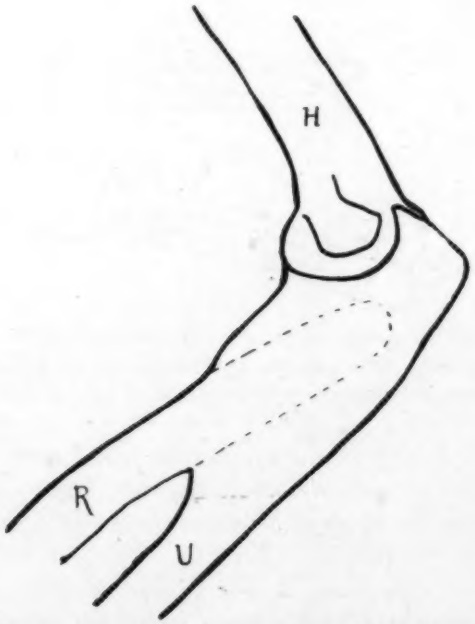

Fig. 38.—Outline of a roentgenogram of the right elbow (reversed) of a woman aged 24. The left elbow gave an identical picture. (From Wilkie, D. P. D.: Brit. J. Surg. **1**:321, 1913.)

Fig. 39. Tracing of a drawing of the left elbow (dissected) in a boy, aged 10 years: *a*, humerus; *b*, radius; *c*, ulna; *d*, capitellum; *e*, trochlea; *f*, head of the radius displaced forward. (From F. C. Abbott, 1892.)

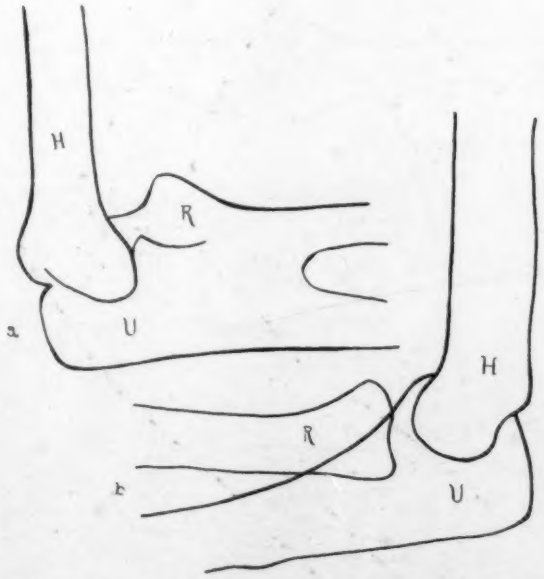

Fig. 40.—Outlines of roentgenograms: *a*, right elbow, showing anterior dislocation of head of radius. Elongation of radius and fusion of radius and ulna, in a girl, aged 15; *b*, normal elbow of girl of the same age. (From Blodgett, 1905.)

Fig. 41.—Outline of a roentgenogram, showing bilateral synostosis in a man, aged 34; *a*, right superior radio-ulnar articulation; *b*, left hand, lateral view. (From Boorstein, 1918.)

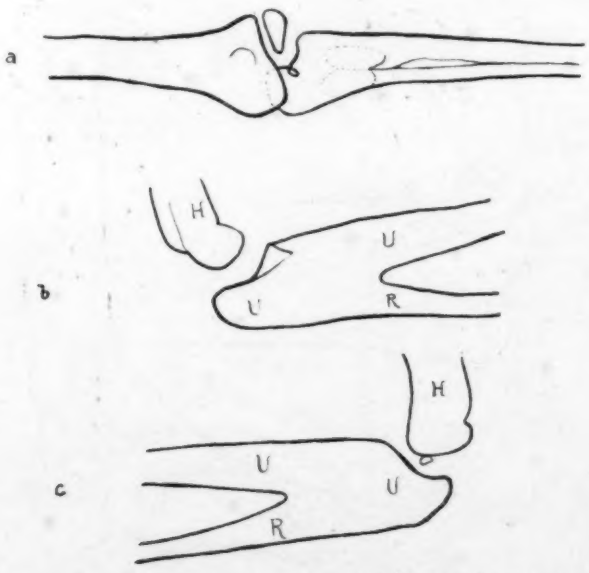

Fig. 42.—Outlines of three roentgenograms, showing bilateral radio-ulnar synostosis in a girl aged 8 years: *a*, anterior-posterior view of left arm; *b*, lateral view of right arm; *c*, lateral view of left arm. (From Sever, J. W.: Surg., Gynec. & Obst. **29**:203 [Aug.] 1919.)

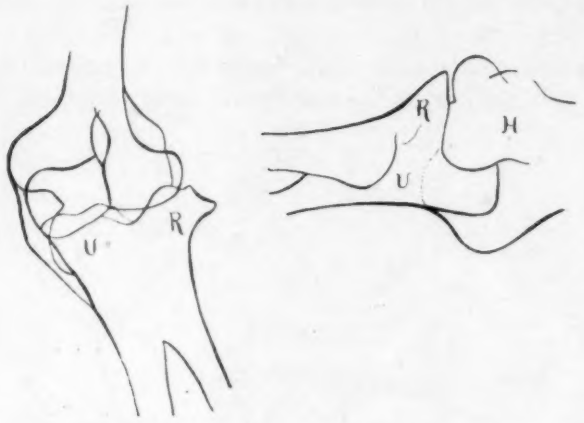

Fig. 43. Outline of a roentgenogram, showing synostosis in a man, aged 40. (From Fortschr. a. d. Gebiete d. Roentgenstrahlen.)

Fig. 44

Fig. 45

Fig. 44.—Outline of a roentgenogram, viewed nearly perpendicularly to sagittal plane, of the left hand of a synostotic subject, a man, aged 34. The region of the bicipital tubercle is affected. (From Wilkie: Brit. J. Surg. **1**:370, 1913.)

Fig. 45.—Outline of a roentgenogram: oblique view of the right elbow. Synostosis of the radius and ulna in the region of the bicipital tubercle, in a man, aged 34. (From Wilkie; compare Figure 44.)

ulna. In Figure 38, the decussation and union are more extensive than usual.

The third type may be called the "dislocated-head" type. It is illustrated by a number of the tracings of roentgenograms to be found

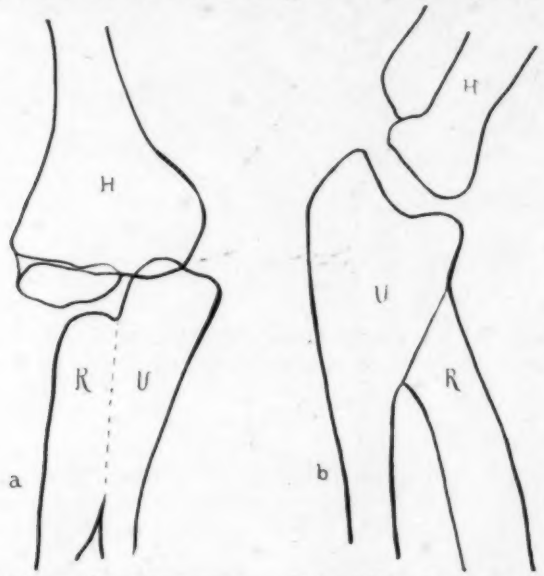

Fig. 46.—Outline of roentgenogram of the elbow of an 8-year-old boy: *a* frontal view; *b*, profile view. (From Martin-Du Pan, 1914.)

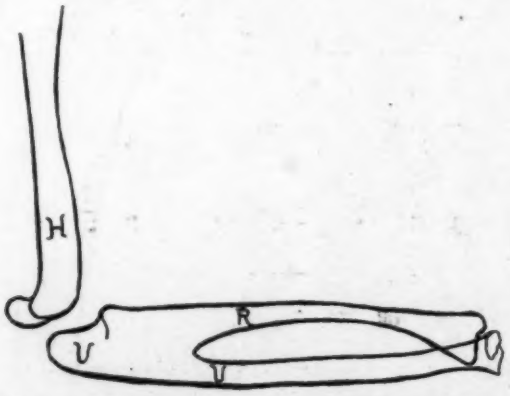

Fig. 47.—Outline of roentgenogram of a boy, aged 12 years. (From Joachimisthal, 1900.)

in the literature. Figure 39 is from a dissection of a case of this sort made before the days of roentgen rays. In this case, the head of the humerus is well developed but, instead of articulating with the capitellum of the humerus, it lies in front of the trochlea. In this position, it must have limited flexion of the arm. Figure 40 is a side view in a case

somewhat similar to the last. The radius and ulna are united, and the radial head is fairly conspicuous. In Figure 42, of an 8-year-old girl, the radius and ulna are closely united side-by-side (42 *a*), and a distinct, though small, radial head is present. Figures 43, 44 and 46 show

Fig. 48.—Outline of roentgenogram of the left elbow of a boy, aged 5½ years. (After Wilkie: Brit. J. Surg. **1**, 1913.)

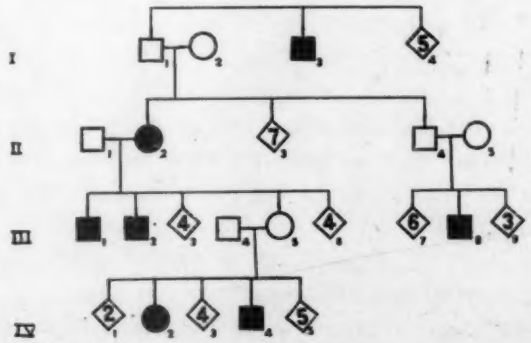

Fig. 49.—Pedigree chart in a case of radio-ulnar synostosis described by Abbott in 1892. The black symbols indicate affected persons; the numbers inside of the symbols indicate the numbers of the family who are of unknown sex.

somewhat similar conditions. Figure 48 shows an instance of interlocking of the ulna with the head of the humerus, in a child of 5½ years.

An examination of these series of outlines leads to the conclusion that there are all grades of bony union and bone displasia in different

cases of synostosis. When union is most intimate, displasia is most profound. This result suggests that, in these cases, there is less a definite new condition than an imperfection in the osteogenic process which varies in degree. This conclusion is strengthened by a comparison of such an outline as Figure 26 with a union for about 6 cm. and Figure 37, with a union for a distance of about 3 cm. and Figure 48 with a union for a distance of less than 1 cm. A similar variability in the degree of union of ulna and radius is found in artiodactyl ungulates; but a given wild species is, in general, probably less variable than man in this respect.

IV. PHYLOGENETIC AND COMPARATIVE HISTORY OF RADIUS AND ULNA

Comparative anatomy, the basis of phylogeny, sufficiently demonstrates that the appendages of man are derived from the fins of fishes and the appendicular skeleton from the skeletal support of those fins. Already, in the amphibia, the skeletal support of the arm distal to the humerus is reduced to two bones, of which the anterior, supporting the carpus, is the radius and the posterior, carrying the elbow-process, the ulna. The great toe both of anterior and posterior appendages is located anteriorly (cephalad), owing to the fact that the appendages stand out approximately perpendicular to the sagittal plane of the body. In the posterior appendage of man, the points of attachment have been drawn together, and in the anterior appendage the humerus has become twisted so that the appendages assume new relations to each other and to the axis of the body. The great toe and the thumb sides of the appendages are now turned, in quadruped fashion, toward the sagittal plane, as seen in the crawling child, and the radius crosses in front of the ulna. When the child assumes the erect position, the plane of the hand comes to lie parallel to the sagittal plane; and the radius passes from the frontolateral aspect of the elbow distally to the front of the ulna; and thus the axis of the radius is merely slightly displaced from the plane which passes through the axis of the ulna.

In reviewing the relations of radius and ulna to each other in the higher vertebrates, we find that they are very variable. While in reptiles they are usually distinct, in recent birds they are usually fused. Among mammals, in the monotremes and marsupiales the radius and ulna, though closely applied, are distinct. In edendates, also, the radius and ulna are distinct and, in the armadillos, capable of considerable rotation. While in the sirenia, the bones of the forearm generally ankylose at the two ends, in the cetacea, though fixed in one plane, they have no bony union. In the proboscidea, on the other hand, the radius crosses the ulna permanently and in hyrax they are often ankylosed, in

old animals. Among the ungulates, the ulna is more or less rudimentary and fixed behind the radius in the ruminants, and still more reduced in the horse. In older mule deer, there is a proximal radio-ulnar synostosis. In the rhinoceros and tapir, the bones are distinct. In the non-ruminant artiodactylia also, the bones are fully formed and distinct from each other. While in rodents, the bones of the forearm are generally distinct; among insectivora there are certain genera (galeopithecus, macroscelides, petrodromus) in which they are fused together distally. In the carnivora, the radius and ulna are always distinct, and there is considerable facility of rotation in the cats. Among bats, the ulna is reduced and ankylosed to the radius. In primates, the radius and ulna are generally distinct and rotation is usually possible, though less in the lower than the higher forms of the order. In referring to these bones in the mammalian series Flower [5] (pp. 269-270) says:

> In their primitive or unmodified condition, these bones may be considered as placed one on each border of the limb, the radius being preaxial, and the ulna postaxial. The radius articulates above with the preaxial (external) side of the humerus, the ulna with the postaxial (internal) side of the humerus.
>
> This position is best illustrated in the fore-limb of the Cetacea, where the two bones are fixed side by side and parallel to each other, the preaxial border being external and the postaxial border internal, in their whole extent.
>
> In the greater number of Mammals, the bones assume a very modified and adaptive position, usually crossing each other in the fore-arm, the radius in front of the ulna, so that the preaxial bone (radius), though external (in the ordinary position of the limb) at the upper end, is internal at the lower end; and the hand being mainly fixed to the radius, also has its preaxial border internal. In the large majority of Mammals the bones are fixed in this position; but in some few, as in Man, a free movement of crossing and uncrossing, or *pronation* and *supination*, as it is termed, is allowed between them, so that they can be placed in their primitive parallel condition, when the hand (which moves with the radius) is said to be supine, or they may be crossed, when the hand is said to be *prone*.
>
> In most Mammals which walk on four limbs, and in which the hand is permanently prone, the ulna is much reduced in size, and the radius increased, especially at the upper end; and the articular surface of the latter, instead of being confined to the external side of the trochlea of the humerus, extends all across its anterior surface, and the two bones, instead of being external and internal, are anterior and posterior.

What is the meaning of this variety in the relations of ulna and radius among the mammals and, indeed, terrestrial vertebrates in general? It is clear that these bones lie close together so that it is easy for them to form osseus connections. It is clear that mutations are occurring in this region, affording the mechanism for hereditary, specific differences. And it is clear that in many species rotation of the fore-

5. Flower, W. H.: Osteology of the Mammalia, London, 1885.

limb would be disadvantageous rather than otherwise, so that a mutation in the direction of synostosis would not be eliminated. For the rest of the interpretation, we must look to embryology.

V. ONTOGENETIC INTERPRETATION OF RADIO-ULNAR SYNOSTOSIS IN MAN

In the human embryo of 3 or 4 weeks, the arm, like the leg, buds out laterally from the body in the amphibian position, nearly perpendicular to the body axis. Later, both appendages become flexed. The arms, which concern us now, are turned toward the ventral side of the trunk, and the palms become applied to the chest; so that the radius and thumb lie cephalad to the ulna. What is called in textbooks of anatomy the "dorsal" or posterior aspect of the forearm now looks ventrally or anteriorly. In this position, the distal end of the radius lies cephalad to the ulna, while the proximal end is ventrad to the ulna. Consequently, in the ventral ("frontal") view, as one passes from wrist to elbow, the radius passes from above to in front of the ulna near the elbow; and a roentgenogram taken from this aspect would show the radius and ulna distinct distally and blended proximally. At the proximal end, the two bones are pressed against each other. Were the radius and ulna united at this point of close approximation (as they are in radio-ulnar synostosis), then, when the arm is straightened and lies parallel to the trunk-axis, the thumb and radial side of the wrist and forearm would be directed ventrad. The hand could be neither fully supinated nor pronated, because the proximal or rotating end of the radius is, in that case, united to the ulna. These are the functional limitations found in radio-ulnar synostosis.

The ontogenetic development of the bones of the forearm has been studied especially by Dr. W. H. Lewis.[6] He showed that they are laid down in the paddle stage at between the fourth and fifth weeks. At the earliest, the precartilage, stage, there is one mesenchymatous plate from which radius, ulna and humerus are to be derived. Later, this membraneous plate is replaced by three cartilageneous rods in each arm. At 5 weeks, "radius and ulna are continuous with the distal end of the humerus." The forearm occupies a position about half way between pronation and supination. The core of each shaft is composed of hyaline cartilage. This is surrounded by a very thick perichondrium, continuous with the condensed tissue at either end of the bone, which encloses the precartilage. At 6 weeks, the skeletal system of the arm is mostly cartilage. It should be noted particularly that "the perichondrium of the proximal end of the radius is continuous with that of the

6. Lewis, W. H.: The Development of the Arm in Man, Am. J. Anat. **1**:145-183, 1902.

adjoining surface of the ulna." "The distal ends of these bones are enlarged and separated from each other by condensed tissue continuous with the perichondrium of each."

From the foregoing description of development, it is clear that the radius and ulna arise in the midst of a single precartilagenous mesenchymatous plate and that, though the transformation of this mesenchymatous plate into cartilage takes place in two distinct centers, the cartilage-forming tissue unites them. In the normal case, the process of chondrification about these two centers stops at a zone such that mesenchymatous tissue separates the two "bones" at all points. In the synostotic case, the process of chondrification goes on across this separating tissue and forms a cartilaginous union. When ossification intervenes throughout the whole cartilaginous ground work, the two bones would show a bony fusion, and there would be a radio-ulnar synostosis. This abnormal extension of the process of chondrification takes place when the two cartilaginous bars lie close to each other, and when, consequently, there is the greatest danger of any abnormal extension of the chondrifying processes leading to a fusion of the two bones.

It would, however, be clearly too narrow a view to conclude that the synostosis is a mere accident. Rather, must we conclude that, through some alteration in the chromosomes, the factors which limit chondrification in the upper arm are weakened; or, possibly, the factor affected has to do with shaping of the precartilage plate. In general, in those cases in which there is a clear inheritance of the condition of synostosis (and doubtless in many other cases where the inheritance is not so obvious), there is probably a gene mutation which alters the various developmental impulses that direct the formation of the proximal end of the skeleton of the forearm.

VI. BONY DEFECTS ASSOCIATED WITH SYNOSTOSIS

The abnormal developmental impulses, of which we have spoken, are sometimes apparently directed merely to the chondrification of the proximal part of the forearm. But, on the other hand, it has been repeatedly observed that individuals having radio-ulnar synostosis and their close relatives suffer other bony defects.

Thus, in the M. family, the affected individuals were all short in stature, while many of those who are unaffected were above average height; and short stature frequently implies imperfect growth impulse in the long bones of the legs. In the R. family, one of the father's brothers and a daughter of one of his sisters had been operated on for extoses. All exostoses are due to growth beyond normal limits, much like that which causes synostosis. The son of still another brother of the father has a left leg which is shorter (congenitally?) than the right.

A cousin of the father is said to have a "hunchback," a defect that in some cases is due to congenital defects in bony growth, although in other cases it is secondary to disease. A kyphosis is found, also, in a sister of the mother in the St. family and in one of her daughters. "Flatfoot" is referred to in two members of the S. family and in one of the St. family. One type of flatfoot is associated with defect in the development of the bones of the feet.

Orthopedic literature contains many instances of other bony defects in synostotic individuals or their families like these illustrated in our own cases. Of these, clubfoot is one of the commonest. This combination is described, for example, by Blodgett,[7] Grünfeld[8] and Martin-DuPan.[9] An instance of fourteen children in one family affected with clubfinger and one also with synostosis is described by Boorstein.[10] In a family with synostosis there was also congenital luxation of the hip (Ahreiner);[11] and, again, bowleg (Roskoschny).[12] Exostoses in the patient or in his close relatives, have been repeatedly found.

Various gross abnormalities in the hand and fingers have been repeatedly described in synostotic families. Joachimsthal's[13] case is especially instructive. A 12-year-old boy, in addition to the sinistral synostosis, had no right thumb and a little rudimentary finger on the radial side of the first phalanx of the index finger. All the bones of the left arm were shorter and thinner than normal. In a brother of this boy, there was the same abnormality of the digits of the right hand; and, on the left side, a "club hand" and union of the upper part of radius to ulna. Two sisters and the mother of these boys show abnormalities in finger development. In Pye-Smith's[14] family, eight of eleven children had abnormal joints, including imperfect supination and pro-

7. Blodgett, W. E.: Congenital Luxation of the Head of the Radius, Am. J. Orthop. Surg. **3**:253-269, 1905.

8. Grünfeld, K.: Ein Fall von radio-ulnarer Synostose, Mitt. Gesellsch. f. inn. Med. u. Kinderh., Wien. **10**:97, 1911.

9. Martin-Du Pan, C.: Trois cas de synostose radio-cubitale congénitale, Rev. méd. de la Suisse Romande. **34**:647-710, 1914.

10. Boorstein, S. W.: Bilateral Congenital Radio-Ulnar Synostosis, Am. J. Surg. **32**:221-223 (Sept.) 1918.

11. Ahreiner, G.: Ueber zwei seltene Formen von angeborener Gelenkankylose, Beitr. z. klin. Chir. Tübingen. **65**:467-471, 1909.

12. Roskoschny, F.: Ein Fall von angeborener, vererbter Verbildung beider Knie- und Ellenbogengelenke, Deutsch. Ztschr. f. Chir., Leipzig **76**:569-580, 1905.

13. Joachimsthal, G.: Eine linkseitige Verwachsung der oberen Abschnitte von Radius und Ulna mit gleichzeitigem Fehlen des Daumens, Fortschr. a. d. Geb. d. Röntgenstrahlen. Erganzungsheft **2**, 1900.

14. Pye-Smith, P. H.: Dislocation Backwards of the Head of the Left Radius, Lancet **2**:993, 1883.

nation, and many of them had ill-formed hands and feet. It has been suggested that cases of the type described by Cushing,[15] in which adjacent phalanges were fused end to end and which showed clear inheritance, really should be considered as mere variants of the condition that appears in radio-ulnar synostosis. It might be maintained that all these cases come under the general rubric of dyschondroplasia; and that the tendency to dyschondroplasia is the thing that is inherited. To this, it must be replied that, in addition, there must be localizing factors; for how else shall we find so many cases of radio-ulnar synostosis only in one family; cases of club foot only in another; and cases of brachydactyly only in another? There seems to be a general tendency to bone malformation and, on top of that, a specific tendency centered in particular bones.

VII. HEREDITY

It is commonly held that, in some cases, radio-ulnar synostosis is an inherited condition. In view of the circumstance that probably fewer than 100 affected individuals have hitherto been described in the literature, the fact that thirteen were said to be affected with synostosis (and five of them had been seen) in one family (the M. family of this study), and the further fact that Abbott[16] found seven cases in one family, five of which he personally observed, would seem to justify this conclusion. An examination of the M. family chart (Fig. 2) shows that all affected individuals descend from an affected parent, and that normal parents in the family have only normal children. This fact suggests the hypothesis that synostosis is a dominant mendelian character. However, it is obvious that the inheritance is complicated, as sometimes, as in Abbott's pedigree, the parents of affected children are, phenotypically, unaffected. Also in the M. pedigree, all but one of the affected individuals are males. A more thorough-going analysis of the inheritance is necessary.

1. *Family Distribution of Synostosis.*—To determine the method of inheritance in our families and in those of the literature which reveal the best evidence of heredity, Table 1 has been drawn up.

In Table 1 certain facts stand out clearly. A larger proportion of the recorded male progeny were affected than of the female progeny; namely, 30/48: 11/42, or as 62.5 per cent. is to 26.2 per cent. of all progeny. Of the affected individuals, 73 per cent. are males. Among the parents, 41 per cent. of the fathers and 15 per cent. of the mothers were affected. The defect is two and one half times as likely to occur

15. Cushing, Harvey: Hereditary Anchylosis of the Proximal Phalangeal Joints (Symphalangism), Genetics **1**:90-106, 1916.

16. Abbott, F. C.: Hereditary Congenital Dislocations of the Radius, Tr. Path. Soc. London **43**:129-139, 1892.

(or be recorded) in males as females. This result is probably associated with the tendency in the male to show larger bony processes, where ligaments are attached, than does the female, as in the case of the occipital protuberance and the mastoid process of the skull; and also in the greater development of the bony ridge or "crista" on the inner face of the diaphysis of the radius. It is probably connected with the fact that the male has a much greater tendency than the female to exostoses (hereditary deforming chondroplasia); in respect to which Ehrenfried [17] concludes that 75 per cent. of the affected individuals are males; about the same percentage as for synostosis.

Table 1 shows, also, that in 55 per cent. of the families one of the parents was synostotic. In eleven cases, it was the father; in four, the mother. In twelve families, neither parent was synostotic, and since in seven of these both parents were seen, it is certain that frequently both parents of synostotic offspring have normal movements of the forearm. In two cases in which neither parent was synostotic, the father had synostotic siblings. In these cases, the defect was clearly carried by phenotypically normal males, in one case even to a daughter.

Of the progeny, twenty-nine had the defect in both arms and twelve in one arm only; six on the right side and six on the left. The unilateral condition tends to run in families. Thus, in the R. and Münter [18] (1899) families, the two or three cases are all unilateral. There is no example of a bilaterally synostotic parent yielding unilateral offspring. One of the twelve unilateral children (Münter) is a descendant of a unilateral, clearly marked synostotic parent; two others (R. family) are from a slightly affected parent, and the others from two unaffected parents. These facts suggest that different family strains are characterized by differences in the degree of activity of the osteogenic processes beyond normal limits just as different species of mammals vary in the degree of fusion of radius and ulna.

The facts that (1) there are varying degrees of synostosis; (2) different families are characterized by differences in this respect; (3) males are more subject to synostosis than females, and (4) inheritance follows different laws in different families indicate that the interpretation of the genetic basis of the defect will not be easy. Moreover, it is not to be forgotten that far more cases have been described without than with a family history showing other cases of the same defect, although in most such cases no serious attempt was made to study the family history.

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17. Ehrenfried, A.: Hereditary Deforming Chondrodysplasia; Multiple Cartilaginous Exostoses, J. A. M. A. **68**:502-508 (Feb. 17) 1917.

18. Münter, O.: Congenitale Luxation des Radiusköpfchens mit Vererbung, Inaug. Diss. Erlangen, Würzburg, 1899.

TABLE 1.—*The Distribution of Radio-Ulnar Synostosis in Families Observed and in Selected Families Described in the Literature.*

Reference	Male Progeny	Female Progeny	Progeny Not Sexed	Father	Father's Siblings	Mother	Mother's Siblings	Remarks
I. M. family	S_2 S_2 S_2 S_2	N N N	....	S_2	11 ♂ N, 4 ♀ N	N	2 N	
M. family	S_2 S_2	N N N N N	....	S_2	3 ♂ S_2, 3 ♀ N	N	.....	Russian Jewish
M. family	S_2 S_2	N N	....	S_2	3 ♂ S_2, 3 ♀ N	N	.....	
M family	N S_2 S_2	S_2	....	S_2	3 ♂ S_2, 3 ♀ N [§]	N	3 ♂ N, 2 ♀ N	
M family	S_2 — —	N N	....	S_2	3 ♂ S_2, 3 ♀ N	N	1 ♂ N, 1 ♀ N	
II. R. family	Sl Sr	N	....	S^a	4 ♂ N, 1 ♂ exos.	N	3 ♂ N, 5 ♀ N	French-Irish catholic
III. A. family {1	N	Sl N	....	N^b	3 ♂ N, 2 ♀ N	N	.....	Russian Jewish
{2	N N	Sr	....	N	1 ♂ N, 1 ♀ N	N		
IV. L. family	N S^{c}_2 N N $S^{1}/_2$	N N S_2	....	N	6 ♂ N, 2 ♀ N	S_2	3 ♂ N, 3 ♀ N	Roumanian Jewish
V. K. family	N^e S_2 N	.....	....	N	1 ♂ N, 1 ♀ N		1 ♀ [g], 2 ♀ N	Russian Jewish
VI. T. family	Sl	N	....	N	3 ♂ N, 1 ♀ N	N^h	1 ♂ N, 1 ♀ N	Austrian Jewish
VII. S. family	S_2	N^t	....	N	4 ♂ N, 2 ♀ N	N	1 ♂ N	German
VIII. St. family	N	Sr N	....	N	1 ♂ N, 2 ♀ N	N	2 ♂ N, 1 ♀ [i], 2 ♀ N	Hungarian Jewish
IX. G. family	N	Sr N	....	N	all N	N	all N	English
X. P. family	S_2	N N	....	N	5 N	N	4 N	Polish Jewish
XI. Pa. family	Sr	.....	....	N^k	.....	N^k	all N	Irish
XII. K. family	N	N N N N N Sl	....	N	8 N	N	.....	Russian Jewish
XIII. Kr. family	N N Sl	.....	....	N	3 ♂ N, 1 ♀ N	N	1 ♂ N, 2 ♀ N	Austrian Jewish
Abbott (1912) 1	S_2 S_2	N	8 N	N	.....	Sr	8 N	
2	S_2	....	9 N	N	1 ♀ Sr^a, 7 N	N		
3	S_2	Sl	11 N	N	2 ♂ Sr, 8 N	N		
Münter (1899)	Sr N	.....	1 N	Sr	.....	N		
Lhermitte et Beuchard (1921)	S_2	.....	2 N	N	.....	S_2	.....	Mother's father S
Polinov u. Levy-Dom. (1911)	S_2 N	N	....	Sr	.....	N		
Blumenthal (1904)	S_2	S_2	....	S_2	.....	N	.....	Father's mother S_2
Roskoschny (1905)	S_2 N	.....	....	S_2	.....	N		
Krelinger (1911)	N	S_2 S_2 N N	....	S_2	1 ♂ Sr	N	.....	Father's father S_2
Total S	17 8 3 1 1	8 1 1 0 1		11	.....	4		
N	10 5 2 1 0	12 10 4 3 1	31 N	16	.....	23		
Total S_1	21,2r 1r 1l 0 0	3r,2l 0 0 0 1l		2r, 1?	.....	2r		
S_2	13 7 2 1 1	3 1 1 0 0		8	.....	2		

[a], slight defect, right forearm; [b], has a club-finger; [c], club foot and knock-knee; [d], probably slight bilateral synostosis; [e], crooked finger; [f], flat feet; [g], achondroplastic; [h], mother's paternal aunt a cripple; [i], hunchback; [k], alcoholic; exos., exostosis; S, synostosis; S_2, bilateral synostosis; Sr, dextral synostosis only; Sl, sinistral synostosis only; N, normal, no synostosis; §, all of same fraternity.

A further analysis of Table 1 indicates, as is so often the case, the presence of distinct genotypical biotypes, characterized by different methods of inheritance. Thus, in the M. family, with thirteen affected members, all but one are males. A study of Figure 2, moreover, reveals the fact that the inheritance seems to be in the male line. This suggests strongly, as Dr. M. Demerec has pointed out to us, inheritance through the Y chromosome. Such inheritance has, indeed, not been found until recently, but two cases have now been described for fish. The first case is that of a black spot on the dorsal fin of the male of Lebistes (Schmidt,[19] Castle [20]). The other is that of the dominant gene for red body color in the Japanese fish *Aplocheilus latipes*, as discovered by Aida.[21] In both cases, the character was transmitted from affected males to males only, since only males receive the Y chromosome. Aida found cases of indubitable crossing over between X and Y, in consequence of which a female appeared with the red color where none was expected. On the hypothesis that a factor for synostosis is carried in the Y chromosome, it would follow that, in the M. family, the single synostotic female is probably produced by crossing over of the gene for synostosis.[22]

The hypothesis of sex limitation is opposed by the large number of affected females among synostotics in general.

Into the biotype of the M. family, the R. family might possibly fall (Fig. 4). But the L. and K. families show an inheritance in the female line, so that in these the gene for the defect cannot be carried in the Y chromosome. In none of the others of our families did one of the parents show the defect. Therefore, in them we probably do not have to do with a dominant gene in the Y chromosome. In Table 2, there are combined all matings in which the sexes of offspring are distinguished and in which one parent is synostotic, and in Table 3, matings of normal parents with synostotic offspring.

Assuming that two factors, A and B, are essential to the expression of synostosis, the cases in Table 2 might be regarded as matings of parents of the types AaBb (synostotic) and aaBb (nonsynostotic).

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19. Schmidt, J.: Racial Investigations. IV. The Genetic Behavior of a Secondary Sexual Character. C. R. Travaux, Carlsberg Lab. **14**, No. 8, 1920.

20. Castle, W. E.: A New Type of Inheritance, Science **53**:339-342, 1921.

21. Aida, T.: On the Inheritance of Color in a Fresh-Water Fish, Aplocheilus latipes Timmick and Schlegel, with Special Reference to Sex-Linked Inheritance, Genetics **6**:554-573, 1921.

22. W. J. Little (in Holmes, T., and Hulkes, T. W.: System of Surgery, Ed. 3, Vol. 2, p. 232, New York: Wood, 1883) states: "We have traced congenital club foot on the paternal side even through four generations, the male infant, the father, the grandfather, and the great grandfather." This again suggests inheritance through the Y chromosome.

Then the synostotic parent would produce gametes AB, Ab, aB, ab; the nonsynostotic parent gametes, aB, ab, and there would be eight possible combinations in the zygotes, namely, AaBB (S), AaBb (S), aaBB (N), aaBb (N), AaBb (S), Aabb (N), aaBb (N), aabb (N); or three S and five N. That the resulting male offspring in Table 2 give eight S to eight N, with a probable error of 1.33,[23] instead of 6:10 may be accounted for by the following consideration. Since we include in

TABLE 2.—*Progeny, Distributed by Sex and Defect of S × N Matings*

Reference	Male Offspring		Female Offspring		Total		Father	Mother
	Affected	Free	Affected	Free	Affected	Free		
R. family	2	0	0	1	2	1	S	N
L. family	2	3	1	2	3	5	N	S
K. family	1	2	...	...	1	2	N	S
Polinov	1	1	0	1	1	2	S	N
Blumenthal	1	0	1	0	2	0	S	N
Roskoschny	1	1	...	...	1	1	S	N
Krelinger	0	1	2	2	2	3	S	N
Totals	8	8	4	6	12	14		

our study only families with at least one affected individual, we tend to overweight the numbers of affected progeny. For, there must be many two-child families which, by chance, have not received the single genoptypic individual to which they are potentially entitled, and which, accordingly, are omitted from consideration. The one-child families are admitted when that child is synostotic and only then. But it is clear

TABLE 3.—*Progeny, Distributed by Sex and Defect of N × N Matings Producing Some Affected Offspring*

Reference	Male Offspring		Female Offspring		Total		Father	Mother
	Affected	Free	Affected	Free	Affected	Free		
A.—1	0	1	1	1	1	2	N	N
—2	0	2	1	0	1	2	N	N
T.	1	0	0	1	1	1	N	N
S.	1	0	0	1	1	1	N	N
St.	0	1	1	1	1	2	N	N
G.	1	0	1	1	2	1	N	N
P.	1	0	0	2	1	2	N	N
Pa.	1	0	0	0	1	0	N	N
K.	0	1	1	5	1	6	N	N
Kr.	1	2	0	0	1	2	N	N
Totals	6	7	5	12	11	19		

that 100 heterozygous parents, each the parent of one child, are expected to produce fifty free and fifty affected offspring. If we reject all of the free and count only the affected progeny, we overweight the "affected" group.

23. The probable error is taken from the useful "Tables of Probable Errors of Mendelian Ratios," issued by the Department of Plant Breeding, Cornell University.

The results presented in Tables 2 and 3 are practically the same. Both tables showed a practical equality of affected and free male offspring, and an excess of females who are unaffected. However, this excess of unaffected females is much greater in the N × N matings than in the S × N matings.

The mating of normal parents, who produce synostotic children, as presented in Table 3, may be conceived of as a union of the nature: AAbb × aaBb; producing gametes Ab, Ab; aB, ab; and zygotes AabBb (S) and Aabb (N) in equal numbers. By the considerations advanced in the last paragraph, one might expect an excess of affected male progeny, but actually the proportion is 6:7 (probable error, 1.22) for the males alone. Since there is reason for thinking that the heterozygous condition of both A and B may sometimes fail of expression, and since this condition alone occurs in the matings presented in Table 3, it may be that the slight reduction below expectation of the number of affected male offspring is due to just this heterozygosity and accompanying incomplete dominance.

Of the families described in the literature, that of Abbott (1912) is of interest because the proportion of affected individuals is so small. Of the three matings, two were N × N and the other N × S_r (maternal). The two N × N matings yield together three affected and twenty free or 1:6/2/3. The N × S_r matings yield two affected to nine normal or 1:3. The latter would result from a mating of the aabb × AaBb type; yielding gametes ab, ab, AB, Ab, ab; and zygotes AaAb, Aabb, aaBb, aabb, of which only the first would, by hypothesis, be synostotic. The former pair of matings, that yielding a 1:6.66 ratio, resembles a trihybrid. Assuming that one parent is AaBbcc and the other aabbCc, then one in eight of the offspring would carry all three dominant factors, and there would result a 1:7 ratio, close to that found (Fig. 49).

2. *Hypotheses.*—To bring all these data together, it is necessary to see if they fit one or more hypotheses.

The hypothesis that the gene is in the Y chromosome is supported only by the M. family and requires the assumption of crossing over. In the other families, there is no evidence of the presence of this gene in the Y or X chromosomes.

Any satisfactory hypothesis of the method of inheritance in synostosis must meet the following conditions: 1. The great preponderance among affected individuals of males over females. 2. The varied ratios of affected to free in different families. 3. The irregularity in expression of the trait, which may be unsymmetrical and varies in extent in the arms of different persons and in the age of full development.

The following hypotheses may be tested: 1. The trait depends on a Y-linked factor. 2. The trait is autosomal, but partially sex limited.

3. Inheritance is modified by imperfection of dominance. 4. The trait depends on multiple factors. Hypothesis 1 cannot apply generally. It may hold for the M. family, combined with crossing over. Hypotheses 2 and 3 may be combined and contrasted with hypothesis 4. As between these two hypotheses, it is difficult to secure definite criteria. On both, generations may be skipped and the degree of expression may be expected to vary.

On the first hypothesis (2 and 3), (*a*) the numerical proportions of occurrence of the trait will be variable and follow no precise law; (*b*) the development of the character will be variable in degree and symmetry; (*c*) the rate for consanguineous marriages need not be abnormally high.

On the second hypothesis (4), (*a*) the trait will occur in the offspring in fairly regular and predictable proportions; (*b*) symmetry is to be expected except perhaps in certain heterozygous situations; (*c*) consanguineous marriages should be frequent, and should be especially so when affected children arise from unaffected parents, since usually only thus will there be a chance of the bringing together of the factors of this rare condition.

In proceeding to these hypotheses, we meet first the difficulty introduced by the difference in sex incidence. Whether this difference is due to sex-linked modifying factors or to some sex-limited factor cannot be said; and our material is insufficient to test these and other hypotheses relating to sex incidence. We have already seen that there are apparently different biotypes; namely, one in which two dominant factors are responsible for synostosis and one in which three such factors are responsible. In the biotypes, expected proportions are nearly met. This result favors the second hypothesis.

3. *The Criterion of Symmetry.*—In bilaterally symmetrical animals, there is usually found a high degree of correlation between right and left sides of the body. When mutations arise, we anticipate that they will be symmetrical, as, indeed, they usually are. However, mutations in bilateral organs are not by any means always symmetrical; and many striking cases of dissymmetry are found in Drosophila—such as "notched (N)" which may occur on one side only (Morgan,[24] p. 378); or "blistered (bs)" (Bridges and Morgan,[25] p. 155). In poultry, one of the authors has studied polydactylism and noted the same lack of

24. Morgan, T. H.: Contributions to the Genetics of Drosophila Melanogaster. IV. A Demonstration of Genes Modifying the Character "Notch," Pub. Carnegia Inst. of Washington, No. 278, pp. 343-387, 1919.

25. Bridges, C. B., and Morgan, T. H.: Contributions to the Genetics of Drosophila Melanogaster, II. The Second Chromosome Group of Mutant Characters, Pub. Carnegie Inst. of Washington, No. 278, p. 304, 1919.

symmetry as well as variability of expression in that character. The clear lack of symmetry of synostosis in some cases favors the hypothesis of imperfection of dominance.

4. *Consanguineous Marriages.*—A dominant character such as synostosis will not skip a generation unless (1) it is the product of two or more independent factors or (2) there is imperfection of dominance. In the first case, both parents must carry at least one factor for the character, and this, in the case of a very rare character like synostosis, implies, usually, relationship. Is there any evidence of relationship in the parents of synostotic offspring, especially when neither parent is synostotic?

First, it may be remarked that a large proportion of the families that we have studied at first hand are Jewish, and thus belong to a race in which consanguineous marriage is notoriously common. Thus, of our thirteen families, nine are Jewish, one German, one French-Irish, one Irish and one English. Even for New York City, this is an undue proportion of Jews.

To summarize, the hypothesis of multiple factors is favored by the vast majority of family histories. The cases in Tables 2 and 3 are in accord with the hypothesis of two factors; but different zygotic constitution of the parents is assumed and phenotypically supported. Abbott's case suggests three factors. In the M. family, there is apparently only one factor. The hypothesis of multiple factors is favored by the fact that consanguinity of the parents is quite possible in most of the matings, probable in several, and one was a marriage of first cousins.

The hypothesis of imperfection of dominance is favored by the great variability of the trait, especially its lack of symmetry. As we have seen, about half of the synostotic individuals show only one arm affected. Such a condition is found also in polydactyl poultry where about 19 per cent. of the heterozygous progeny show the dominant trait on only one appendage (Davenport,[26] p. 19). It is found in polydactylous guinea-pigs (Castle,[27] p. 22), where the extra toe is best developed on the left side. Such asymmetry is found in human polydactylism also (Davenport,[28] Ballowitz[29]). Finally, in human exostoses, there is usually a marked lack of symmetry. The left femur may carry a bony tumor and the right be without it; while the right

26. Davenport, C. B.: Inheritance of Characteristics in Domestic Fowl, Pub. Carnegie Inst. of Washington, No. 121, 1909.

27. Castle, W. E.: The Origin of a Polydactylous Race of Guinea-Pigs, Pub. Carnegie Inst. of Washington, No. 49, pp. 17-29, 1906.

28. Davenport, C. B.: Wonder Horses and Mendelism, Science **19**:151-153, 1904.

29. Ballowitz, E.: Ueber hyperdaktyliche Familien und die Vererbung der Vielfingrigkeit., Arch. f. Rassen u. Gesellsch. Biol. **1**:347-365, 1904.

arm bones may have tumors and the left be free. These exostoses may be present even at birth. They are clearly due to developmental impulses, but these impulses are not symmetrically directed.

Apart from lack of symmetry, synostotic individuals vary in degree of expression of the trait. Thus, the propositus in the M. family can pronate (right 135, left 90 degrees); the propositus in the L. family pronates the right and the left each to 110 degrees; in the K. family, the propositus pronates (right 135, left 140 degrees), and his mother pronates also (right, 160 degrees). In the S. family pronation is: right 120, left 130 degrees, and so on. The degree of synostosis is seen to vary in the roentgenograms. Sometimes, the union extends through 2 cm., at other times, through 4 or 6 cm. All of these facts point to variability in degree of expression of the trait; and to a variable imperfection of dominance. Such a variability of expression is found in bony fusions of the phalanges by Cushing.[15]

VIII. CONCLUSIONS

On the whole, the evidence seems to favor the conclusion that there is some truth in all of the hypotheses and that radio-ulnar synostosis is a trait that, in different biotypes, depends on one, two or three factors; that it is usually an autosomal dominant (although the possibility that the gene for it may lie in the Y chromosome of certain families should be kept in mind), and that it is partially sex limited but variable in degree of expression, possibly owing to modifying factors.

IX. SUMMARY

1. Radio-ulnar synostosis varies greatly in degree. Two fairly distinct types may be distinguished; (*a*) the type in which the radius head is absent, the proximal end of the radius being fused with the ulna, and (*b*) the type in which the head of the radius is displaced toward the flexor side of the arm. The extent of the bony union varies from about 2 to 6 cm.

2. A comparative review of the mammalia shows that the radius and ulna are frequently united. This union is associated partly with their close proximity, so that any overgrowth of either bone may cause a permanent fusion of the two. When the use of the anterior appendage is not seriously interfered with, this union may become normal for a species, genus or family.

3. The radius and ulna develop out of the same precartilage plate, and, at a later stage, the perichondrium of the two bones is continuous at their proximal ends.

4. The abnormal developmental impulses which lead to synostosis are indicated by other bony defects in the propositus or his family. Among the commonest of these are: exostoses, clubfoot and clubhand,

flatfoot, abnormally diminished growth of long bones, short stature and bowlegs; in general, dyschondroplasia.

5. There are genotypical differences in the various families, which thus belong to diverse biotypes. In one family (M.), only one gene appears to be responsible for the synostosis, and this acts much as though in the Y chromosome (but this is highly uncertain). In most families, distribution is that of a two-gene trait; in one of the families, of a three-gene trait. The synostosis is always a dominant trait.

6. Males are twice as likely to be affected as females; and this result holds for bone defects in general.

7. Frequent lack of symmetry in the defect suggests that there is frequent imperfection of dominance.

8. Consanguineous matings are found in the synostotic families; and it is probably that they are especially frequent in them.

9. Radio-ulnar synostosis appears to be a dominant partially sex-limited trait, which varies in degree of expression.

SEPTIC THROMBOPHLEBITIS OF FEMORAL VEIN, OPERATIVE TREATMENT

WITH REPORT OF CASE *

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Septic thrombophlebitis, irrespective of its site, always induces a serious clinical picture, frequently with unfavorable prognosis. Whether it involves the lateral sinus, a tributory of the portal vein, the pelvic veins or veins of the extremities, insidious and progressive advance of the thrombus is the usual course. The clot laden with bacteria softens, and small particles with engulfed micro-organisms enter the blood stream. For a time, the showers of micro-organisms are apparently destroyed by the bactericidal agents of the body. Blood cultures are then not invariably positive. The condition is an intermittent bacteremia (Martin [1]). The prognosis depends on many factors, but it is largely a question of the ratio between the number, type and virulence of the micro-organisms and the resistance of the host.

In general, the infection overwhelms the resistance. Organisms are arrested by the liver or lung, with resulting abscess formation therein, or they pass through these organs and give rise to metastatic abscesses in more remote parts. The pathetic and protracted picture of pyemia is the concomitant of this pathologic process. No conservative therapeutic measures are successful. But since the serious results are due to the direct communication of the infected vessel with the blood stream, the mind instinctively turns to the possibility of early isolation of the infection by mechanical measures. This idea of surgical intervention in such cases has been practiced to a limited extent. Although of relatively recent development, it has some historical background.

It is said that John Hunter, in the eighteenth century, recommended compression of the vein above the thrombus in order to produce adhesive occlusion of the vessel above the obstruction. Apparently, the first operation was performed by Lee,[2] who, in 1865, cured several cases of purulent thrombophlebitis of superficial veins of the extremities by

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* Read before the College of Surgeons, Philadelphia, Nov. 7, 1923.

1. Martin, W.: The Significance of Bacteria in the Blood Stream, Ann. Surg. **76**:421 (Oct.) 1922.

2. Lee, H.: The Surgical Treatment of Certain Cases of Acute Inflammation of the Veins, Med. Times Gaz. **1**:530, 1865.

ligation of the veins above the affected areas. In 1877, Kraussold [3] cured a case of pyemia following infection of an amputation wound by ligation of the femoral vein above the thrombus and resection of a portion of the venous trunk. Demons,[4] 1881, in a case of suppurative thrombophlebitis of the median basilic and cephalic veins, successfully evacuated the thrombi. A few other early cases were reported in the domain of general surgery, but it was in the field of otology that ligation of the venous trunk and evacuation of the thrombus was shown to have real merit. Forty-three years ago, Zaufal [5] proposed exposure of the sinus, with evacuation of the infected thrombus, and ligation of the jugular vein, in sinus thrombosis following middle ear suppuration. He first performed the operation in 1884.

In gynecology, the operation of "phlebectomy" has had a varied and not very encouraging career since it was first employed by Freund, [6] in 1898. He reported two cases of puerperal pyemia in which he excised the obstructed ovarian vein and thrombotic broad ligament. These operations proved unsuccessful, as did three others reported by Bumm [7] in 1902. For the frequent cases of puerperal pyemia in which the veins are obstructed on both sides, bilateral ligation was proposed by Trendelenburg,[8] who has reported several successful operations; one in 1911 with recovery after transperitoneal ligature of the vena cava and the ovarian veins.

More recently, Martens [9] (1921) has operated in eleven gynecologic cases of thrombophlebitic pyemia, two successful ligations of the vena cava being included. In the other cases, the ovarian veins were ligated on one or both sides, and in addition the hypogastric or the common iliac veins. Of the eleven patients, seven recovered. Martens advises an extraperitoneal approach.

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3. Kraussold, H.: Ueber eine operative Methode zur Bekämpfung beginnender Pyaemie, Arch. f. klin. Chir. **22**:965, 1878.

4. Demons: Contribution au traitment antiseptique des phlébites, Bull. et mém. Soc. de chir. **7**:878, 1881.

5. Zaufal, H.: Sinusthrombose, Prager med. Wchnschr., 1880, No. 52, p. 517; Operation der Sinusthrombose, Prager med. Wchnschr., 1884, No. 48, p. 474; Ein durch Operation geheilter Fall septisch-otitischer Sinus-thrombose, Prager med. Wchnschr., 1896, No. 49, p. 558.

6. Freund, W. A.: Beitr. z. Geb. u. Gynäk., 1898, p. 343; Ueber Komplikationen der Uterusmyome, speziell über Varikosität und Nekrose, Centralbl. f. Gynäk., 1900, No. 40, p. 1042.

7. Bumm, E.: Berl. klin. Wchnschr., 1905, No. 27, p. 829; Ueber die chirurgische Behandlung des Kindbettfiebers, Centralbl. f. Gynäk., 1902, No. 8, p. 218.

8. Trendelenburg, F.: Beckenhochlagerung und Lungenembolien, Prakt. Ergeb. d. Geburtsh. u. Gynäk., 1911, Pt. 1; Centralbl. f. Chir., 1911, No. 14, p. 512; Ueber die chirurgische Behandlung der puerperalen Pyaemie, München. med. Wchnschr. **49**:513, 1902.

9. Martens, M.: Ueber Venenunterbindungen bei thrombo-phlebitischer Pyaemie Verhandl. d. deutsch. Gesellsch. f. Chir. **45**:246, Part 2, 1921.

With respect to the intestinal tract, the literature contains a few cases in which thrombophlebitic obstructions of the mesenteric veins have been successfully operated on. The first of these was reported by Brunner,[10] in 1907. Wilms,[11] in 1909, in a case of pyemia originating in the appendix, ligated the mesenteric veins at the angle between the cecum and ileum, with the result that the chills were promptly arrested and the patient made a good recovery. Braun,[12] in 1913, elaborated this operation by ligating the ileocolic vein shortly before its entrance into the superior mesenteric and resecting the thrombosed vessel, with success in two cases. Weil,[13] in 1920, reported a case of pyemia of appendiceal origin cured by this procedure.

The femoral vein is a frequent site of thrombosis, and occasionally of septic or suppurative thrombophlebitis; yet surgical intervention is infrequent. Operative efforts in such cases have been so rarely reported that one wonders whether the possibilities of benefit by operation have not been generally overlooked. We are led to believe that many cases susceptible of benefit by operative treatment have been conservatively treated until death because of the conviction that signs of sepsis always indicate a general infection which cannot be controlled by local measures. Gluck,[14] in 1896, reported several successful cases, in one of which there was thrombophlebitis of the long saphenous vein seven weeks after abortion. The patient suffered from high fever, chills, icterus, enlargement of liver and spleen and weakened heart action. The treatment consisted in ligation of the common femoral vein, and the patient recovered. In a case of saphenous thrombosis, the patient was successfully operated on by Müller,[15] in 1909, by ligature of the femoral vein. Riedel,[16] in 1911, reported a case in which he had removed a septic thrombus from the femoral vein.

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10. Brunner, F.: Ein durch Operation geheilter Fall von septischer Thrombose der Mesenterialvenen, Deutsch. Ztschr. f. Chir. **89**:624, 1907.

11. Wilms: Venenunterbindung bei eitriger Pfortaderthrombose nach Appendicitis, Centralbl. f. Chir. **36**:1042, 1909.

12. Braun, H.: Die Unterbindung der Vena ileocolica bei mesenterialer Pyaemie nach Appendicitis, Beitr. z. klin. Chir. **86**:314, 1913.

13. Weil: Zur Pathologie und Therapie der Thrombophlebitis mesaraica, Berl. klin. Wchnschr. **57**:270, 1920.

14. Gluck, T.: Beitrag. zur chirurgischen Behandlung infektioser Thromben, Deutsch. med. Wchnschr. **22**:606, 1896.

15. Müller, W.: Zur operativen Behandlung infektiöser und benigner Venenthrombosen, Arch. f. klin. Chir. **66**:642, 1902; Zur Prophylaxe der Lungenmbolie bei Schenkelvenenthrombose, Verhandl. d. deutsch. Gesellsch. f. Chir. (38th Kongress) **1**:151, 1909.

16. Riedel: Doppelseitige Thrombose der Venae femorales nach schwerem Dickdarmkatarrh, Deutsch. med. Wchnschr. **37**:961, 1911.

In this country, Greiss,[17] in 1913, observed septic thrombosis of the femoral vein four weeks after an operation for gunshot wound of the intestine. He exposed and incised the thrombosed vein; removed the thrombus, and resected 6 inches (15 cm.) of the vessel. The patient recovered. Rost,[18] in 1916, in two cases in which amputation of the leg was followed by septic manifestations suggestive of thrombophlebitis, ligated the trunk of the femoral vein. Recovery ensued.

Rosenstein,[19] having observed a number of cases, recommends high ligation of the external iliac vein in selected cases of septic thrombosis of the femoral vein. He emphasizes that the essential feature of the operation consists in central ligation well above the thrombus. His first successful case was that of a man of 54 years with varicose ulcer of the leg and thrombophlebitis of the right femoral vein. The femoral vein was ligated, with extirpation of the entire thrombotic trunk. In the second patient, a woman with mastitis and thrombosis of the femoral vein, ligation of the common iliac vein was performed, followed by extirpation of the entire thrombotic portion as far as the saphenous vein. The outcome was good. The third case was one of progressive thrombosis in a woman, 28 years of age. The ligature was applied in healthy tissues directly below the bifurcation of the common iliac vein, and the thrombotic venous segment was resected as far as the saphenous. The patient made a good recovery. Another case in which the upper extremity was involved occurred during Rosenstein's service in a field hospital and concerned a young soldier whose left arm had been amputated. Subsequently, disarticulation at the shoulder joint had to be performed, on account of infection. After temporary improvement, general sepsis developed, due to progressive thrombosis. The subclavian vein was exposed below the clavicle, and was found to be thrombosed at this site, with inflammatory changes in the surrounding tissues. Accordingly, a ligation was performed in healthy tissues, fairly close to the origin of the vessel, and the patient made a prompt recovery.

A similar case was observed by one of us (E. H. P.).

April 11, 1918, a French soldier was admitted to Evacuation Hospital No. 1 A. E. F., representing multiple wounds of leg, forearm and thorax. The forearm presented advanced gas bacillus infection. The patient was in profound shock. After reaction from shock, disarticulation at the elbow was performed under local anesthesia without moving the patient from bed. Six hundred cubic

17. Griess, W.: Gunshot Wound of Abdomen Followed by Septic Venous Thrombosis of Femoral; Operation, Recovery, Lancet **110**:34, 1913.

18. Rost: Ueber Venenunterbindung wegen Pyaemie bei Extremitätenverletzungen, München. med. Wchnschr. **63**:573, 1916.

19. Rosenstein, P.: Die Phlebektomie (operative Ausschaltung der fortschreitenden Thrombophlebitis), Arch. f. klin. Chir. **109**:394, 1917-1918.

centimeters of 5 per cent. sodium bicarbonate solution was administered intravenously, Bull's serum, 10 c.c., being injected through the infusion tube. Much improvement resulted. Hemothorax was present.

April 13: The temperature had followed a septic course since admission, reaching 103 F. The pulse ranged from 100 to 110. Bull's serum, 10 c.c., was given. The red blood cells numbered 1,600,000. Hemoglobin was 38 per cent. Transfusion was made into the internal saphenous vein. Local evidence of brachial vein thrombosis developed. Without moving the patient from bed, the operator ligated the vein in the axilla, and incised downward, and the suppurating clot was removed. The wound was left open and was treated by the Carrell-Dakin method. There was progressive improvement, and the patient was discharged, May 15.

In two cases of septic thrombophlebitis of the great saphenous and femoral veins reported by Santrucek,[20] in 1920, the septic manifestations subsided at once after ligature of the femoral vein. In a third case, in which there were as yet no symptoms of propagation of the septic material through the blood current, the femoral vein was ligated as a prophylactic measure. The patient made a good recovery. Such prophylactic venous ligation and resection is advocated by Hosemann [21] because of seven successful cases.

Postoperative femoral thrombosis following aseptic celiotomy is quite frequently noted, and much interest is attached to this condition on account of the obscurity of its origin and the occasional serious sequelae. Clark [22] found thirty-six cases of thrombosis in a series of 3,000 celiotomies. The theories as to the origin of the thrombi have been collected and elaborated by Albanus,[23] Aschoff,[24] Conner,[25] Clark [22] and others. They need not be reviewed, and only a brief reference will be made to this phase of the subject. Aschoff states that "Thrombosis is the function of a number of variables. There is not a single cause, but quite a number of different conditions which are closely related to the occurrence of thrombosis. Among these may be mentioned, first, changes in the blood plasma (diminished or increased coagulability); secondly, changes in the blood elements (increased or diminished powers of agglutination); thirdly, changes in the blood flow

20. Santrucek, K.: Die eitrige Thrombophlebitis und ihre Behandlung, Centralbl. f. Chir. **47**:984, 1920.

21. Hosemann: Vorbeugende und kurative Venenunterbindungen bei infektiösen Thrombosen im Felde, Med. Klin. **12**:1169, 1916.

22. Clark: Etiology of Postoperative Femoral Phlebitis, Univ. Pennsylvania M. Bull. **15**:154, 1902-1903.

23. Albanus, G.: Thrombosen und Embolien nach Laparotomien, Beitr. z. klin. Chir. **40**:311, 1903.

24. Aschoff, Ludwig: Beitr. z. Thrombosefrage, Leipzig, 1912; Thrombosis, Arch. Int. Med. **12**:503 (Nov.) 1913.

25. Conner, L. A.: Nelson Loose-Leaf Medicine, New York, Thomas Nelson and Son, 1920.

(slowing and formation of eddies), and lastly, changes in the vessel wall itself (endothelial damage). An inquiry into the mechanism of thrombosis shows that sometimes one factor, sometimes another, plays the principal rôle." Clark concludes that postoperative thrombophlebitis is referable to traumatism exerted on the deep epigastric vessels during the operation. Originating in the deep epigastric vein, the primary thrombosis, he believes, is slowly propagated along the vessel until it reaches the external iliac, where it gives rise to a retrogressive thrombus in the femoral vein, usually on the left side. While this explanation is doubtless applicable to a certain proportion of cases, it does not readily account for thrombosis following a high incision nor thrombosis of the left femoral following operations through the right abdominal wall. Some years ago, we had a case, which is of interest in connection with Clark's theory. Fatal pulmonary thrombosis followed an operation for right inguinal hernia during the course of which the deep epigastric vessels had been ligated and divided. Necropsy revealed a thrombus in the pulmonary artery which completely obstructed the vessel. The upper part of the right femoral vein contained fluid blood, the walls were smooth and glistening except a large valve immediately beneath Poupart's ligament. Three inches (7.5 cm.) below Poupart's ligament, the vein was occupied by a thrombus which extended downward for 2 or 3 inches. The upper part of the thrombus was soft and very friable; the lower portions were more cohesive. It was assumed that the thrombus originated in the deep epigastric stump and extended thence into the femoral, the upper portion of the femoral thrombus giving rise to the pulmonary embolus (New York Hospital history number 209768, Jan. 4, 1917).

The rare cases in which the postoperative thrombus is laden with bacteria constituting a septic thrombus, as in the case to be reported, must be explained as due to hematogenous infection, with localization and colonization of pyogenic organisms in the vessel wall (Matas[26]).

The clinical picture of septic thrombophlebitis has been described by Matas and will not be discussed. When the veins of the extremities are affected, the diagnosis should not as a rule occasion much difficulty because of the intensity of the local and systemic signs and symptoms.

The case on which this paper is based follows.

REPORT OF CASE

History.—A man, English, aged 34, married, a janitor, admitted, Feb. 16, 1923, to the Second Medical Service, New York Hospital, for years had had attacks of indigestion, the pain coming on two to three hours after eating. He has had occasional night attacks. Relief was obtained by belching and

26. Matas, R.: The Operative Treatment of Acute Septic Thrombophlebitis, Keen's Surgery **5**:150, 1909, Philadelphia, W. B. Saunders Company.

vomiting. No severe attacks had occurred for the past six years, but there was a feeling of epigastric fulness and discomfort after meals. The stools had been tarry two weeks before admission.

Physical Examination.—The patient was a poorly nourished intelligent man. The heart, lungs and abdomen were negative. The urine was negative. The blood count was normal.

The clinical diagnosis was duodenal ulcer and chronic appendicitis.

Operation.—The ulcer of the duodenum was excised, and the appendix was removed.

Pathologic Report.—There was round cell infiltration of the duodenal ulcer.

Course.—For four days after operation, the temperature was slightly elevated. It then became normal and remained so until the sixteenth day after operation. The wound healed by primary union. On the sixteenth day, the temperature rose suddenly to 104 F. and then followed a septic course, ranging from 99 to 105 F. until April 23, the sixty-third day after operation. During this time, the patient had gone down hill steadily. He was having chills and sweats but complained only of headache. Repeated blood counts varied between 10,000 and 17,000, with a polymorphonucleosis. The patient was markedly septic and very weak. He was repeatedly examined without anything definite being found until March 28, when evidence of phlebitis of the internal saphenous vein was noted. Blood culture taken, March 26, showed hemolytic streptococci. March 29 and April 3, blood cultures were sterile. One taken, April 12, again showed hemolytic streptococci.

April 23 (sixty-third postoperative day), under local anesthesia the left femoral vein was exposed, ligated and opened, and the thrombus was removed.

Operation.—A 3 inch (7.5 cm.) incision was made over the upper portion of femoral vein, and the vein was exposed. Pressure was maintained digitally over the region of the inferior vena cava about 1 inch (2.5 cm.) above and to the right of the umbilicus. There was a friable thrombus which broke into fragments during removal. One segment projected like a cork into the profunda femoris artery. When this was removed, there was free bleeding from this artery. An aspirator and also a gallbladder clamp was introduced proximally through the opening in the femoral vein, but no clot was obtained from above. The total length of the thrombus removed was about 3 inches. The internal saphenous vein was ligated and the femoral vein was ligated at each end of the wound. The profunda was also ligated. The wound was left open. The pathologist reported that the thrombus contained gram-positive cocci arranged in pairs and chains.

Following operation, the patient improved wonderfully. He had no more chills or sweats. The temperature dropped to from 99 to 101 F. and blood cultures were repeatedly negative. May 14, under local anesthesia, a left popliteal abscess containing hemolytic streptococci was incised and drained. Following this, the temperature remained normal, and improvement continued.

The patient was kept in bed six weeks in order to favor the development of venous channels to minimize the effects of the femoral obstruction. At first, the extremity was markedly swollen, but the swelling gradually diminished, and since the patient has been up and about, there has been little swelling and no subjective symptoms. The patient was examined, October 1, five months after operation. His general health is excellent and he has gained 20 pounds (9 kg.). He returned to work one week after discharge. He has no pain in the limb. There is slight swelling at the end of the day, because of which a bandage is worn.

The measurements are: Right thigh, 18½ inches (46.2 cm.), calf, 12½ inches (31.2 cm.); left thigh, 20 inches (50 cm.), calf, 13¼ inches (33.1 cm.). There is slight pitting over the dorsum of the foot, but no local tenderness or cyanosis.

Some features of the case are worthy of review.

The patient was septic, losing ground rapidly, with positive blood culture and an essentially negative physical examination except for a left femoral phlebitis.

The phlebitis was presumably secondary to some undiscovered focus. At the time of ligation, we hoped that it was the only active focus. That this was the case is supported by the subsequent clinical course.

The low grade fever which the patient ran following the second operation received full explanation when a popliteal abscess was evacuated. Temperature then immediately dropped to normal and remained normal. This popliteal collection was evidently the result of a slow suppurative, retrograde thrombophlebitis from the site of ligation downward.

Although the operation was successful, the operative procedure could have been improved in several details, as will be noted later.

CONCLUSIONS

It is often possible to explain the occurrence of suppurative thrombophlebitis; for instance, a large vein in proximity to a suppurating area so that pyogenic bacteria penetrate its wall, as the lateral sinus in mastoiditis; or involvement of small efferent veins in a pus focus, with extension of the thrombi into the larger venous trunks, as pylephlebitis complicating acute appendicitis. Yet in many cases the explanation is impossible.

A septic thrombus is, at first, frequently a local and solitary focus of infection. From it, micro-organisms are passed into the general circulation and may be recognized by blood cultures. The clinical picture is one of septicemia. This condition prevails for a variable period before secondary abscesses or septic infarcts develop. Under such conditions, isolation of the infection by proximal ligation of the vein may arrest the disease. The prognosis under such treatment is most favorable in early cases, especially when blood cultures are not constantly positive, indicating an intermittent bacteremia. When the thrombus is one of multiple foci in a general infection, the infection is beyond control.

A patient who presents the signs of phlebitis with unexplained persistent septic temperature and positive blood cultures is entitled to operation upon the involved vein if this is accessible. One never hesitates to drain an abscess, and the same general rule should apply to infections in veins, with the added indication that an infection in a vein is infinitely more dangerous because it is so situated as to threaten the general blood stream.

The operation can be performed on veins of the extremities under local anesthesia without serious discomfort to the patient.

As to the question of delaying ligation in the presence of suppurative thrombophlebitis because of doubt as to the competency of the collateral circulation, let it be borne in mind that a thrombosed vein is no more effective than a ligated vein in the matter of carrying on the circulation.

In the surgical treatment of suppurative thrombophlebitis, the necessity for central ligature of the venous trunk is obvious, and it must always be the guiding rule to operate in uninvolved tissues. Hence, in thrombosis of the femoral vein, the external iliac vein should be exposed. It should be determined by inspection and careful palpation, and if necessary by incision, that the exposure is above the thrombus. Until the thrombosed vein has been occluded by ligature, it is wise to interpose some block above the vein on the cardiac side to minimize the chances of setting fragments free. Therefore, digital pressure should be maintained on the vena cava during these preliminary procedures. After it has been demonstrated that the exposure is above the thrombus, the vein should be ligated. It is better, as pointed out by Rosenstein, to ligate a few centimeters too high than to work in diseased tissues. In some cases, this is all that can be done either because of the condition of the patient or because of the situation of the vein. As has been shown, a number of cases have been cured by this procedure. But, in general, the thrombus should be removed. This may be done in several ways. The vein may be split downward and the upper end of the thrombus identified and the incision continued, if possible the full length of thrombus, which should be removed with or without the vein wall; or the unopened vein and thrombus may be removed together. Interference is always advisable as soon as the condition of suppurative thrombophlebitis has been recognized. In view of the fact that the operation in itself is practically devoid of danger; all other measures are inefficient, and the disease in severe cases is almost invariably fatal, surgical interference is definitely indicated.

FORMATION OF DECIDUA OF PREGNANCY IN ADENOMA ENDOMETRIOIDES OVARII *

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William Wood Russell (1899) and at about the same time the German authors von Franqué (1898), Naumann (1898), Agnes von Babo (1900) and Vassmer (1901) reported findings of endometrial tissue in the ovary. The organ in these cases was only slightly enlarged, and contained strands and ramifications of a tissue which showed in all its details the structure of the physiologic mucous membrane of the uterine body. That this pathologic condition is also of definite clinical importance was first demonstrated by Pick in 1905,[1] who reported four cases from the operative material of Landau's clinic (Berlin). In the second and fourth cases, there were bilateral or unilateral ovarian cysts ranging from the size of an apple to that of a goose egg, and the operation in these cases consisted of oophorectomy solely for this condition. The tissue of the lining of the cysts was found to be identical with the uterine body mucous membrane, and Pick named this condition adenoma (or cystoma) endometrioides ovarii. His description seems to have been overlooked in the subsequent literature, although his article fully describes all of the macroscopic and microscopic peculiarities of the condition. The characteristics according to Pick are as follows: 1. Cysts reaching the size of a hen's egg or an apple and containing chocolate brown, tarry fluid. 2. Lining these cysts, a mucous membrane-like layer showing all the histologic features of the corpus uteri. 3. The participation of this mucous membrane in the menstrual function or other aperiodic congestion of the female genitalia; as a proof of this hyperemia, macroscopically yellowish brown or brownish red staining of the mucous membrane-like lining; and microscopically yellowish brown intracellular iron containing granules in stroma elements and in epithelium. 4. A connection of the endometrial strands which penetrate the organ and partially form cysts, with the superficial epithelium of the ovary. 5. Genesis of the cysts from dilatation of the endometrial glands as a result of the periodic (menstrual) or aperiodic hemorrhages, and confluence of the smaller cysts with their chocolate brown syrupy contents into larger cysts.

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* From the Pathologic Institute of Krankenhaus Friedrichschain; Director of Department of Pathology, Prof. Ludwig Pick.

1. Pick, L.: Ueber Neubildungen am Genitale bei Zwittern, Arch. f. Gynäk. **76**, No. 2, 1905.

Cases of endometrium in the ovary have been of late fairly numerous in the American literature, although the cases of appreciably enlarged ovaries, according to the type of Pick, are considerably fewer.

Norris[2] (1921) reports a case of an ovary 3 by 2 by 1.85 cm. containing endometrium in the same menstrual stage as the uterine curettings. Cullen says:

> Casler (February, 1919) describes a case in which the patient menstruated through the vaginal vault, after a complete hysterectomy in which one ovary was saved. The uterus was removed for an adenomyoma, which contained stroma but no glands. Four years later, the ovary was removed and found to be the size of a medium grape fruit. On histological examination, great quantities of typical uterine mucosa were found scattered through the ovarian tumor, thus clearly explaining why the patient continued to menstruate without any uterus. The ovary contained all the essential elements, normal ova and practically normal uterine mucosa, and the small tract left where the uterus had been removed supplied the necessary avenue, along which the menstrual flow escaped.

Cullen[3] (1920) summarizes the foregoing cases, and reports two of his own cases and a case of Dr. Schwarz:

> CASE 1.—Small cyst of left ovary—ovary 6 cm. long, 2 to 3 cm. thick. Ovarian cyst lined by brownish membrane: the cyst has an inner lining of cylindrical epithelium which here and there tends to form folds. At some points beneath the epithelium there is a definite stroma and imbedded in this are a few glands. The cyst is partially filled with blood.
>
> CASE 2.—On the posterior surface of the cervix and lower part of the body of the uterus was the most widespread adenomyoma of the rectovaginal septum I have ever seen. On the surface of and intimately attached to the right ovary was a miniature uterine cavity. The glands in this showed a moderate hypertrophy. Other sections from the same ovary showed a diffuse adenomyoma intimately blended with the ovarian tissue, so intimately that no line of demarcation could be detected.
>
> It must be remembered that this ovary was firmly glued to and continuous with the diffuse adenomyoma that occupied the posterior surface of the uterus. It is quite possible that the uterine mucosa on the surface of this ovary was due to an overflow of the adenomyoma of the rectovaginal septum.
>
> CASE 3 (Dr. Schwarz).—Ovary size of a hen's egg, showed nothing unusual externally. On section it showed several cavities which were filled with blood partly clotted. Two large blocks were cut transversely across the ovary. The sections show the lesion well demarcated from the rest of the stroma of the ovary. There are two cavities. These are lined with tissue similar to that of the endometrium. The sections are a beautiful example of an ovary containing miniature uterine cavities.

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2. Norris, C. C.: Ovary Containing Endometrium, Am. J. Obst. & Gynec. **1**:831-834 (May) 1921.

3. Cullen, T. S.: Distribution of Adenomyomas Containing Uterine Mucosa, Arch. Surg. **1**:215 (Sept.) 1920.

Sampson [4] reports twenty-three cases of perforating hemorrhagic cysts of the ovary. The cysts in his cases were usually small, from 2 to 4 cm. in diameter, and contained chocolate brown fluid. He says:

> In two patients operated on at the time of the menstrual period, one the day that menstruation was due, and the other the last day of menstruation, the histological changes in the ovarian endometrial tissue corresponded to the phase of the menstrual cycle indicated by the menstrual history. Sampson believes that the material escaping from the ovarial hematomas may give rise to the development of adenoma of endometrial type in the tissues thus soiled, i. e., peritoneal implantations.

From the point of view of general pathology, adenoma endometroides ovarii belongs to the large group of formations which Recklinghausen described in general for the uterus and fallopian tube, as adenomyoma. Following him, these formations were described not only in numerous parts of the female genitalia, fornix vagina, uteroovarian ligament, ligamentum rotundum, uterosacral ligament, rectovaginal septum, etc., but also in other parts of the abdomen. Lauche [5] has recently written at length on the extragenital heterotopic adenomyoma. He emphasizes the participation in menstruation and illustrates with macroscopic and microscopic findings.

I shall not go into the genesis of these tumors. Whether, as Recklinghausen and Pick maintained, their anlage is from the wolffian body, or whether, as Pick later thought, from the superficial epithelium of the plica urogenitalis; whether they come from the epithelium of Müller's duct or from the peritoneal epithelium, will not concern us here; but certainly we cannot, as R. Meyer maintains, consider the entire celom epithelium to be everywhere of such a quality as could produce such endometrial tissue. Meyer compares the endometrial formations produced by the peritoneal epithelium with the glandlike formations seen in some cases of pericarditis. But these two conditions cannot be put in the same category. An endometrial growth on the pleura or pericardium has never been observed. The characteristic cytogenous stroma, with its small round and spindle shaped elements and delicate fibers between them, makes the resemblance to the uterine mucosa so decided that we can in no way compare this condition to any of the findings on the pleura or pericardium.

The much discussed nomenclature—neoplasma (adenomyoma) or inflammation (adenomyositis)—will not be treated here. Lauche, of late, argues for the neoplasmic character of at least a part of these formations.

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4. Sampson: Perforating Hemorrhagic (Chocolate) Cysts of the Ovary, Arch. Surg. **3**:245 (Sept.) 1921.

5. Lauche, A.: Die Extragenitalen heterotopen Epithelwucherungen Von Bau der Uterusschleimhaut, Virchow's Arch. f. path. Anat. **243**, April, 1923.

While there is no question that at least the genital extra-uterine endometrial growths participate in the menstrual function, it is a close step to their participation in a further functional change in the endometrium; that is, the decidual formation.

It is a well-known fact that the decidual reaction extends beyond the narrow localization of the embryo, whether in extra-uterine or intra-uterine gestation. I refer only to the decidual nodules so frequently seen in the pouch of Douglas, the omentum, the appendix serosa, the perisinous tissue of the pelvic lymph nodes (Geipel [6]) or on the peritoneum of the diaphragm (Geipel); also in perimetritic, perisalpingitic and perioophoritic adhesions, or even on the surface of the otherwise normal ovary. Rosenberger [7] has summarized heterotopic decidual findings. But such decidual formations in ordinary connective tissue have always been small or insignificant, either microscopic or at best tubercle-sized groups. One would expect that in the often macroscopically extensive endometrioid projections of strands the decidual formation would occur on a large scale. And indeed this has actually been shown. Amos,[8] in 1905, reported decidual formation in the mucous membrane of a uterus adenomyoma associated with a decidual-like transformation in a connective tissue tumor of the abdominal wall. This tumor of the abdominal wall, at first insignificant in size, increased greatly during pregnancy. Cullen [3] reported decidua of pregnancy in a rectovaginal septum endometrioid growth. One would expect this decidual reaction the more in the relatively large ovarian cysts, where there is often a massive endometrial lining.

To demonstrate the foregoing point, Professor Pick kindly allowed me to report one of the cases from his material in the Pathologic Institute, Krankenhaus Friedrichshain, Berlin.

REPORT OF CASE

History.—A married woman, aged 35, admitted to the surgical service of the Friedrichshain Hospital, March 15, 1922, with a negative family history, as a child had an injury to the left ankle joint. The menses began at the age of 16. At first the periods were irregular, then regular and profuse, with pain. She had had one child, thirteen years previous to admission. There were postpartum complications, inflammation of the left ankle joint and suppuration of one of the left inguinal glands. She had had an appendectomy twelve years before admission. The last period, according to the patient, sixteen days prior to

6. Geipel: Deciduaähnlichen Wucherungen auf dem Zwerchfell, Centralbl. f. Gynäk. **150**:1457 (Sept.) 1922.

7. Rosenberger: Die Pathologisch-Anatomische Diagnose der Salpingitis Isthmica nodosa unter Zuhilfenahme der Dezidual Reaction, Arch. f. Gynäk. **114**, No. 3, 1921.

8. Amos: Decidua in Adenomyom und Bauchdeckentumor, Ztschr. f. Geburtsh. u. Gynäk. **54**:171, 1905.

admission, lasted one day. Eight days later, she suddenly began to have severe pain in the left lower abodmen and frequent chills and fever. The family physician made a tentative diagnosis of extra-uterine pregnancy, and referred her to the hospital.

Physical Examination.—The patient was a fairly healthy looking woman of medium size, with a deformity of the left foot. Except for the abdominal and pelvic findings, the examination was negative. The lower abdomen was somewhat resistant and sensitive to pressure, especially to the left. The pelvic examination, March 15, showed that the uterus was in anteflexion, relatively enlarged, slender, with portio admitting the end of a finger. The right parametrium was much shortened; the tube of lead pencil thickness; the ovary normal sized and sensitive to pressure.

The left parametrium was shortened less, the tube thickened and the ovary enlarged.

A diagnosis of tubo-ovarian disease complicating pregnancy was made.

On examination, March 20, the uterus was drawn to the left, to within two fingers' breadth below the umbilicus. The right parametrium was much shortened, and the adnexae were not palpable. In the left parametrium, a fist-sized doughy swelling, which was sensitive to pressure, could be felt.

Operation (March 22).—A soft cystic left ovary was revealed, the size of a hen's egg. On puncture, a chocolate brown fluid was evacuated. The ovary was removed.

The operation did not affect the pregnant uterus. The patient made an uneventful recovery and was discharged seventeen days after operation.

Pathologic Examination.—The fallopian tube was 5 cm. long. It was not thickened. The infundibulum, which was patent, was attached by a delicate ligamentum latum to a tumor corresponding to the ovary. The tumor was cystic, and about the size of a hen's egg. The contents had been evacuated. The surface of the tumor resembled that of the normal ovary, with no adhesions. The inside of the cyst was in some places grayish red, in others, yellowish brown. It was not smooth, but in part coarsely granular, and part had distinct nodular elevations. The elevations and granules were soft in consistency. On the cut surface, of the same color as the inside of the cyst, the elevations especially were stippled with fine needle point grooves. Granules and elevations formed a mucous membrane-like layer of from 0.5 to 3 mm. in thickness, and were attached to the shell of ovarian tissue by a delicate connective tissue membrane. Thus, the cyst wall had two layers: (1) the outer, a hard ovarian tissue and (2) the inner, a soft mucous membrane-like formation.

Microscopic Examination.—A number of sections were taken through the entire thickness of the cyst wall. They included the large humplike elevations and the small granules. They were hardened in formaldehyd, and frozen and paraffin sections were made. Hämalaun and eosin and van Gieson's stains were employed, with Perl's test.

The microscopic picture obtained may be divided into three groups:

Group I. Corresponding to the macroscopic findings of two layers of the cyst wall, the outer of harder consistency, the inner of softer, the outer layer (Fig. 2 *os;* Fig. 4 *ocs*) was shown, microscopically, to be made up of the typical ovarian cortical stroma. It consisted of finely interlacing bundles of spindle cells in close approximation. The physiologic epithelial components were lacking. Not infrequently, especially in the superficial layer of the stroma, small irregular lime flakes, single or in groups, were found, some almost round and in concentric layers. Germinal epithelium was lacking.

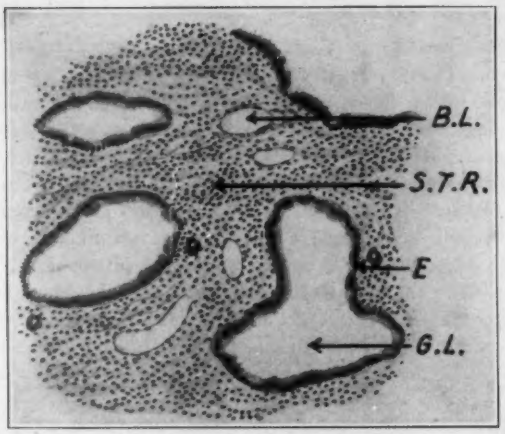

Fig. 1.—Section of the endometrioid layer (inner layer) of the ovarian cyst; reproduction of the corpus uteri mucous membrane; *gl,* glandular tube; *e,* glandular epithelium; *str,* lymphadenoid stroma; *bl,* capillary blood vessel (Leitz oc., 1; obj. 4; tube length, 165 mm.; paraffin, hemalum-eosin).

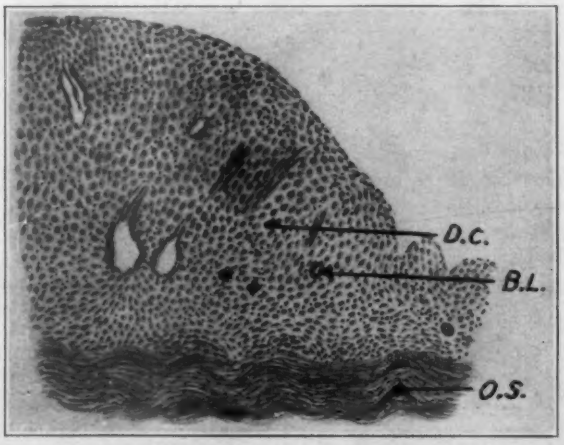

Fig. 2.—Section of the decidual layer (inner layer) of the ovarian cyst; reproduction of the compact layer of decidua of pregnancy; *bl,* small blood vessel; *os,* ovarian cortical stroma; very abrupt transition to the decidua, *dc;* (Leitz oc., 1 obj. 4; tube length, 160 mm.; paraffin, hemalum-eosin).

On some parts of the surface were the remains of fine connective tissue adhesions; in other places, there was on the surface of the rich spindle cell stroma a distinct layer of connective tissue poor in cells (Fig. 4 *aak*), the direction of whose fibers was parallel to the surface. Especially in this part of the ovary, we see, in the physiologic cortical stroma, glandlike formations or smaller or larger cysts (Fig. 4 *gl*), lined with a single row of cuboidal or higher epithelium. These were directly imbedded in the stroma. The smaller cysts were usually round, but some of the larger ones were more irregular.

The inner layer of the main cyst wall gave in many places no other picture than that of the uterine body mucosa (Figs. 1 and 4). The transition from outer to inner cyst wall was abrupt (Fig. 4). The thickness of the mucous membrane (in the sections after shrinking) was still nearly 3 mm., corresponding to the macroscopic humplike elevations. The stroma of this mucous membrane (Fig. 1 and Fig. 4 *str*) was the typical lymphadenoid of "cytogenic" tissue, consisting of the very small round and spindle shaped elements with delicate fibers between them, as is the rule in this tissue. The details were even better seen on account of the separation of the components by a marked edema. The

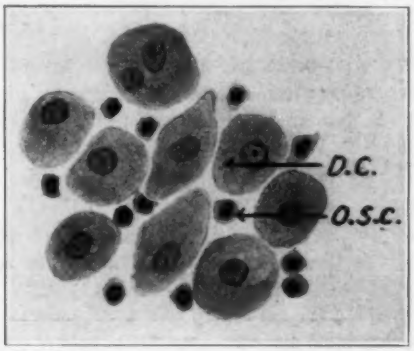

Fig. 3.—Field from decidua, Figure 2; *dc*, decidual cells; **osc**, original stroma cells (Leitz Oc., 4; obj. 6; tube length, 165 mm.; paraffin, hemalum-eosin).

blood vessels were fine capillaries (Fig. 1 *bl*) and precapillaries, but in a few places somewhat larger tortuous arteries. The glands (*gl*) were in general tubular, but were often somewhat widened or serrated, and were lined by a single layer of low cylindrical epithelium (*e*). The plasma was homogeneous, clearly stained by eosin. The nuclei were oval, in midposition, and contained a moderate amount of chromatin. The glands were mostly empty, but some contained fine granular pinkish stained masses, discharged epithelium or free nuclei or hyaline globules, with an intensive eosin stain.

The layer of endometrioid membrane was, of course, thinner in the situation of the smaller granules, or was even much reduced in the depressions between the nodules; but in any case, the components of the mucous membrane, stroma glands and their epithelium were everywhere clearly seen. The superficial mucous membrane epithelium was in many places preserved and corresponded perfectly to the glandular.

In the macroscopically yellowish brown regions, and also in some of the macroscopically colorless parts was found pigment attached to the stroma cells. Here the stroma cells were larger, somewhat round or polyhedral, and showed

yellowish brown flakes or granules crowded together in the protoplasm and often displacing the nuclei peripherally. Other elements were more diffusely yellowish brown. All the pigment gave a positive iron reaction (Berlin blue).

Group II. The outer layer of the cystic wall was about the same as in Group I. The inner layer was entirely different. Here, nearly all the endometrial components were lacking, except for some superficial mucous membrane epithelium. The whole mucous membrane resembled, in all its details, the substantia compacta of pregnancy (Fig. 2). Here also the components were especially well seen, owing to a mild edema in several situations. The decidual elements (Figs. 2 *dc* and 3), round or slightly polyhedral, measured on stained section in general 30 microns in diameter. Sometimes, they exceeded this size, chiefly when they had a more elipsoid or even spindle shaped form and here the diameter was more than 40 microns. In contrast, the physiologic stroma cells (Fig. 3 *osc*) still preserved between the decidual cells, measured from 6 to 8

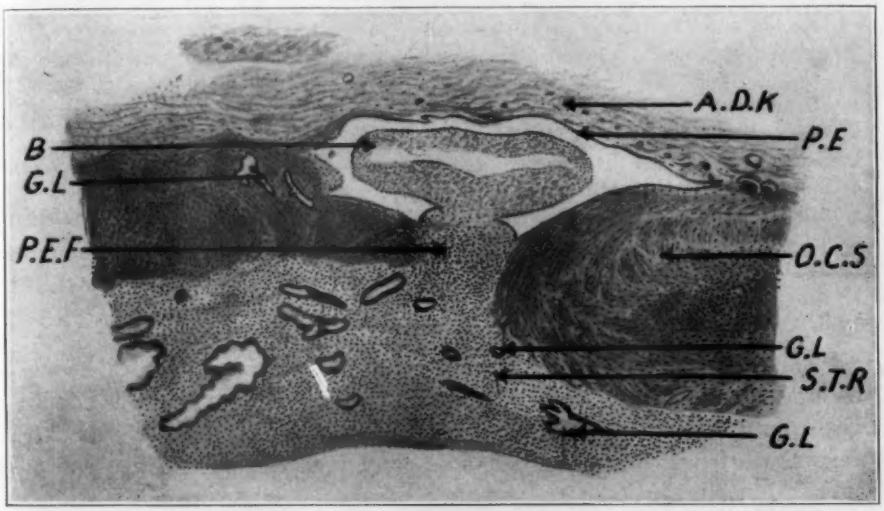

Fig. 4.—Section through cortical zone, inner layer and superficial adhesions of the ovarian cyst; inner layer of the character of the corpus uteri mucous membrane; *str*, lymphadenoid stroma; *gl*, tubular glands; *osc*, ovarian cortical stroma (the inner layer perforates it, *pef*, and ends in a bud, *b*, of decidual character); *gl*, glandular formations in the cortical stroma; *adk*, tissue of the fibrous adhesions; *pe*, peritoneal epithelium (Leitz Oc., 1; obj. 1; tube length, 160 mm.).

microns. The protoplasm of the decidual cells was stained light blue with hemalum and pinkish with eosin. The nuclei were large globular or elipsoid, the longest diameter 14 microns, poor in chromatin and therefore vesicular, with a more or less visible nucleolus. The nucleus was usually simple and central, but was sometimes double. The number of stroma cells still preserved corresponded to the number usually found in the substantia compacta of the pregnant uterus, so that the chief difference here is the entire absence of glands. Toward the outer layer (cortical stroma of the ovary), the diameter of the decidual cells became smaller (compare Fig. 2), but here, too, the borderline between the two

layers was still very sharp. The blood vessels (Fig. 2 *bl*) were capillaries and small arteries as in Group I, but here also small dilated veins were well seen.

Group III. This group showed in one field (*a*) the combined pictures of Groups I and II. Not infrequently, immediately beside the typical unchanged corpus mucous membrane could be seen, in an abrupt transition, the decidual changes through the entire thickness of the endometrium-like layer (*b*). Or else the formation of decidual cells was only abortive, and there were fields where the glands were still present, but the stroma cells were considerably larger than the normal group. All these different pictures of Groups I, II and III were irregularly distributed over the surface of the cyst, and gave most variable combinations. The humplike elevations might represent a large amount of corpus endometrium, or just as well a perfect decidua. In general, the decidua was best developed in those places in which the endometrium and its stroma was likewise well developed.

Especially noteworthy were a few instances of a change in the normal relations between the outer stroma (ovarian cortex) and the inner layer (body endometrium or decidua). The inner layer in smaller or larger strands penetrated the outer and reached the surface. A clear instance of this is shown in Figure 4 *pef*. The endometrium was itself not changed into decidua, but a small prominent plug (*b*) in the form of a closed loop between adhesions on the surface, (*adk*), although free from glands, showed a complete decidual transformation. Here also the germinal epithelium was preserved, and the peritoneal epithelium (*pe*) between the adhesions themselves, so that sections through the adhesions gave the appearance of glandular ramifications. Lime deposits as mentioned above in the cortical zone were sometimes relatively numerous also in the endometrium-like mucous membrane, or even in the decidua in various localities.

The fallopian tube showed no special changes, no decidual formation.

This tumor represents in its type the characteristic adenoma endometrioides ovarii of Pick. The cyst, the size of a hen's egg, and necessitating oophorectomy, was lined by a membrane, the form and thickness of which represented a hypertrophic endometrium corporis uteri. It contained a thick choloclate brown material; macroscopically, pigment changes on the inner surface, and, microscopically, iron containing intracellular pigment deposits.

The patient was pregnant (uterus two fingers breadth below the umbilicus), and, as shown above, the endometrium corporis uteri in the ovarium participated in the formation of decidua of pregnancy, with so typical a histologic picture that the pathologist, without knowledge of the clinical history, diagnosed pregnancy from the specimen.

The decidual formation takes place in a peculiar manner. As described above the endometrium was not everywhere of the same thickness, and varied from about 0.5 to 3 mm. The decidual reaction was neither generalized, nor did it particularly affect the regions with the best developed endometrium. Rather, it was entirely unevenly distributed and also variable in its intensity. Frequently enough, we see the entire inner layer completely transformed into a decidua compacta

(without glands). But immediately bordering on these situations, we see pure endometrium without decidual changes; in other places more or less decidual-like hypertrophy of the cells; and all of these pictures are variously combined. The humplike elevations or granules consist sometimes of pure decidua and sometimes of pure hypertrophic endometrium. Possibly, the hypertrophy of the endometrium was also due to the pregnant condition. At any rate, this coarsely granular and uneven inner surface of the lining of the cystoma, adenoma endometrioides ovarii, is very unusual.

The connection of the endometrial membrane with the surface of the ovary, as Pick postulates, in adenoma endometrioides ovarii, is here shown at its best. The stroma of the outer (cortical) layer of the cyst is perforated by broad circumscribed straits of endometrioid character, and it is quite interesting that we find again a little bud of endometrium prominent on the surface (Fig. 4), this bud being decidual while the endometrium strait itself is free from decidual cells. It is also important that just in this situation we find, microscopically, remnants of an old oophoritis in the form of connective tissue bands. Possibly, the ingrowth of the glandlike formation and its development into endometrial tissue was due to the localized inflammatory irritation. As a sign of ingrowth, we have, as Pick previously described, the small scattered cysts in the cortical zone, often immediately beneath the surface. The development of cytogenous stroma comes later.

In brief, in our case, we have not only a participation of the endometrial cyst lining in the menstrual function, as is evidenced by the chocolate brown contents and the characteristic hemosiderin pigment, but we have a positive reaction in pregnancy, a perfect decidual formation with extensive distribution. We have a cyst which, on account of the functional changes in its endometroid lining, produced complications of pregnancy, and symptoms necessitating operative interference.

UNUNITED FRACTURES

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A fracture is usually classed as ununited when there is free motion between fragments at the end of six months. However, there is no arbitrary time when distinction can be made between delayed union and nonunion. If stability gradually increases, the prognosis for solid union is good; and only after a stationary period has been reached without effort to consolidate can the fracture be designated as ununited. The length of time differs according to the seat of the fracture and to local and constitutional conditions. For instance, if no union occurs in a central or intracapsular fracture of the neck of the femur at the end of eight weeks, in all probability an ununited fracture exists. Failure of bony union is more frequent in the neck of the femur than elsewhere, and presents such a distinct and definite problem that a brief discussion will be made of ununited fractures of this region, before this condition in other bones is considered.

A complete report of cases and methods used in the treatment of ununited fractures of the neck of the femur has been published in previous contributions. Clinical experience teaches us that under the most favorable circumstances union is delayed in this region, and, as stated, a permanent status of nonunion is reached much earlier. Consequently, radical measures are instituted sooner, consisting in inserting a massive autogenous graft from the tibia or fibula through the neck of the femur across the line of fracture, thus holding the fragments together. We have employed this method in more than fifty cases and have found that bony union, with satisfactory results, decreases inversely as the length of time increases after the occurrence of the fracture. In all those cases in which operation was performed in less than a year, solid bony union was obtained, and in those performed during the second year not more than 50 per cent. were successful. Thereafter the chance of success rapidly declines. The autogenous graft of dense into spongy bone is usually absorbed, but may remain in situ without apparent change for many years. In one case, the graft remained five years.

Ununited fractures of other points of the skeleton occur with increasing frequency, which may be the sequence to the actual occurrence of a greater number of fractures, as a result of the development of the automobile and other industrial activities; but the quantity alone does

not account for the increase in fractures which fail to unite. This is probably due to two factors:

1. A change in type and nature of fractures, as evidenced by more multiple fractures when several bones are broken, making a greater demand on callus output, with defective union in one or more fractures, and more severe trauma to the soft parts, impeding circulation; or by
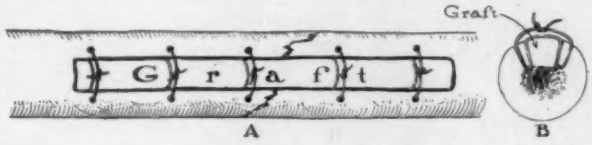
Fig. 1.—Usual inlay bone graft held in place with ligatures of kangaroo tendon or catgut.

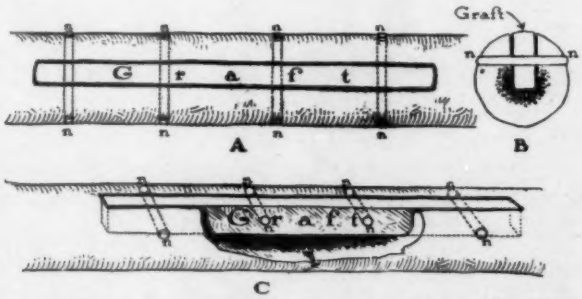

Fig. 2.—*A*, modification of the ordinary inlay graft when extreme strength and stability are required; bone nails extending through graft and cortex on both sides; *B*, cross section showing graft extending well down into medulla; *C*, graft 1.5 cm. wide placed edgewise in narrow groove in cortex of bone; section of cortex removed to show graft in place on lateral view.

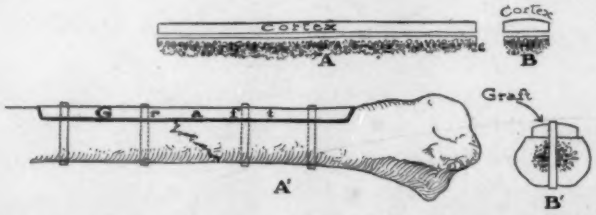

Fig. 3.—Longitudinal division of transplant which is firmly held by autogenous bone nails.

direct injury to the bone, impairing osteogenesis. There are also a larger number of compound fractures in which union is always retarded.

2. An evolution in the treatment of fractures to meet the demands of the roentgen-ray, which at times is exacting, often requiring too frequent manipulations in an effort to produce a satisfactory reduction from a roentgenographic standpoint. Such repeated trauma may impair the natural process of repair. Resort to open operative reduction is too

frequently employed, delaying union by mere incision and, in many instances, causing further damage by trauma to the periosteum and soft parts. Should infection complicate, the insult to nature is obviously greater.

In a review of 1,555 fractures, from private records, only seventy-six open reductions were found, a higher percentage than should occur in the average run of fractures, as many are referred to the specialist on account of unusual complications.

The etiology in nonunion is constitutional and local. The constitutional causes are:

1. Focal infection producing a general toxemia and often mild anemia. Infected teeth are possibly the most frequent source.

2. Hypothyroidism and hyperthyroidism. Each condition has been associated in a few instances.

3. Syphilis, malaria, diabetes or any debilitating affection. In no case has active syphilis been a causative agent, though in quite a number there was late syphilis or parasyphilis

The common local causes, in order of importance, are:

1. Improper reduction with wide separation of fragments.

2. Inefficient fixation, an important factor, as there has not occurred one case of nonunion in which continued fixation has been routinely employed, in 1,555 cases.

3. Interference with circulation by severence of the nutrient artery.

4. Interposition of fascia and soft tissues. This has not been observed in a single instance, though it is quite possible this cause may not be apparent at the time of operation.

The pathology, symptoms and physical signs are too well known to require narration, except in one type, which will be briefly described. Only two such cases have been observed, both in the lower third of the tibia, with fragments well approximated. After many months or years, following apparent union, the symptoms are pain, slight swelling and limp, after standing or walking, causing material disability. The roentgen ray shows exuberant callus and apparently solid union. The patient is able to demonstrate feeble motion between fragments, which is elicited with much difficulty by the surgeon. In one case, the condition had persisted for three years. At operation, there was massive, external callus, somewhat pliable and not organized into dense bone. Between the fragments there was a separation of possibly one fourth of an inch, which was filled by dense fibrocartilage with scattered areas of bone. The line of fracture was evidently obscured in roentgenograms by external or periosteal callus. There was probably a deficiency in endosteal osteogenesis. The discovery of this condition, to which no reference could be found in the literature, proves that nonunion occurs in varying degrees and that even should there be sufficient stability to permit normal weight bearing, an ununited fracture may, rarely, exist.

Figure 4

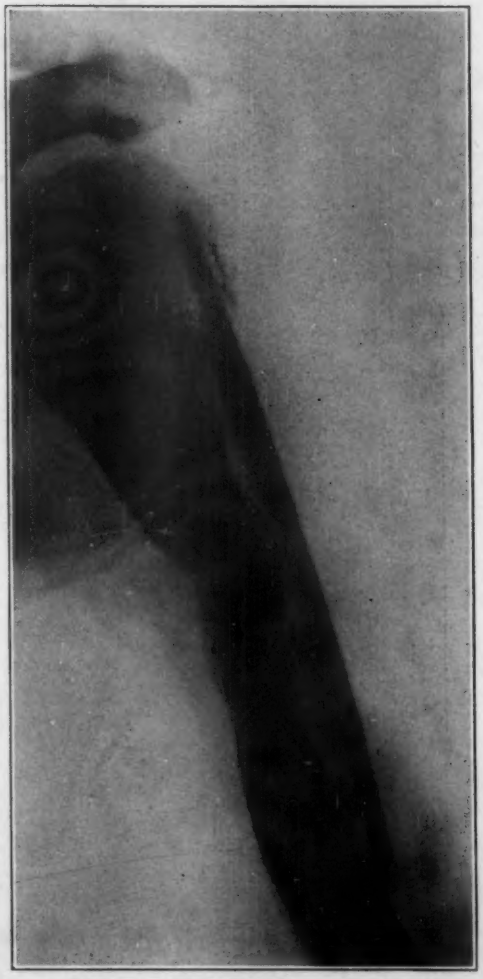

Figure 5

Fig. 4.—Massive grafts with autogenous bone nails in both bones of the forearm; solid union in eight weeks.

Fig. 5.—Satisfactory massive grafs of upper third of humerus, securing perfect fixation and resulting in solid union and restoration of function.

Figure 6

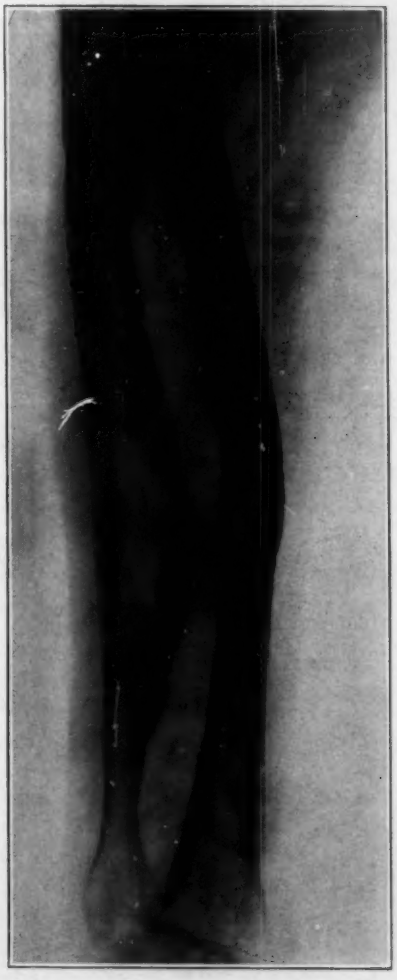

Figure 7

Fig. 6.—Typical ununited fracture of humerus with cavity of false joint on proximal fragment.

Fig. 7.—Massive graft restoring anatomic alinement of ulna, extending practically entire length of the bone.

It also accounts for quite a number of cases attended by persistent pain, without discernable cause, much longer than should be expected. When these symptoms do not abate after general and local treatment has been persistently administered, radical operative procedures alone are indicated.

The roentgenographic findings are of interest and may demonstrate extensive bone atrophy of both fragments, but are more pronounced in the distal. The fragments may taper to points or cones or form a definite false joint in which the proximal fragment is the receiving cavity; or there may be excessive callus on both fragments which does not seem to have the power to penetrate the line of fracture. Endosteal callus is apparently absent, as has been observed at operation, and may have a causative relation to nonunion.

The treatment is prophylactic, constitutional and local. In every fracture of consequence, there should be a complete physical and clinical examintion, and elimination of all defects, by which nonunion would often be avoided. In ununited fractures, the cause, if obscure and remote, can often be ascertained and removed, but usually without the slightest effect on the local condition which is so completely developed that aid from this source cannot be expected. However, chances of success by subsequent treatment is materially enhanced.

Local massage, electricity and active motion are indicated when there are trophic changes in the soft parts, but, as a rule, are a mere waste of time even as a preliminary to operation. Such measures as stimulating fragments by friction pounding or the injection of blood or irritants are too uncertain to be worthy of trial, except in delayed union, which is not under discussion.

In order to obtain union in a large percentage, there are two important factors which must at all times be considered and rigidly observed: (1) complete internal fixation and (2) osteogenesis, which operative measures as more generally employed do not take into account. These methods are:

1. Simple paring of the fragments, placing in apposition and applying external fixation, of value in early cases when there is wide separation of fragments.

2. Application of metal plates, as the Lane, which may secure perfect internal fixation, but inhibits osteogenesis as demonstrated by roengenograms which show callus only on the opposite side of the bone from the steel plate. Subsequent irritation and infection are well known objections.

3. The employment of animal bone plates and pegs, better tolerated but of about the same action as metal—a foreign body which may not be absorbed for many years.

Fig. 8.—Steel nails attempting to hold small grafts, securing no fixation, and the most inadequate means of treatment.

4. The autogenous bone graft—a most indefinite procedure without standardization. When a hysterectomy or an appendectomy has been performed, it is well known what has been accomplished, but a "bone-graft" may indicate a thin plate or peg between two surfaces, a mere caricature of an efficient procedure.

I have employed the autogenous bone graft by all of the well known methods, with success in a large percentage, but solid internal fixation could rarely, if ever, be attained; which was a constant reminder that if this could be accomplished, the percentage of satisfactory results might be increased and union secured in less time with earlier function than had hitherto been obtained. With this view, and employing the massive graft as advocated by Henderson, which secures internal fixation, the following technic was evolved [1]:

An ample incision is made through the skin in order to expose each fragment, when possible, for 4 inches (10 cm.). Routine dissection is made to the seat of fracture; all intervening scar and fibrous tissue is removed; the fragments are pared with chisel or motor saw, and each medulla is reamed out until normal marrow tissue is reached. The fragments are rotated until normal relation has been restored. An incision is made through the periosteum of each fragment, for several inches, depending on the length and the anatomic location. The periosteum is stripped from one-half to three-fourths inch (1.3 to 1.9 cm.) from the circumference, leaving attached, as much as possible, the soft parts from which circulation is derived. With a chisel, "shavings" are removed from the circumference until there is a continuous flat surface, for 3 or 4 inches (7.5 or 10 cm.), when possible, on each fragment. A broad flat massive graft is taken from the tibia, which should be of sufficient length, breadth and dimensions to secure firm fixation. With a motor saw, the graft is split longitudinally through the edge or small diameter into two parts, a strong outer plate consisting of dense bone or cortex, and an inner, the endosteum. A strip of endosteum is placed within the medulla, bridging the seat of the fracture as reduction is made, normal marrow tissue rich in osteoblasts being thus restored. From the outer plate, or as a separate graft, a strip of dense bone is taken, from which six or eight autogenous bone nails are made, of appropriate size. The strong outer plate is held to the flat surface of the bone, passing across the seat of fracture. Three or four drill holes are made through the graft and each fragment, into which the autogenous bone nails are driven. A square peg in a round hole secures firm attachment. In addition, chronic catgut sutures are passed about the bone and graft. The remainder of the endosteum is broken into small particles and placed with the "shavings" about the seat of fracture. If the graft is taken from the upper extremity of the tibia, it is often possible to obtain small pieces of spongy bone, which are possibly more active in reproduction than dense bone.

With a limited number of femora and humeri, a different technic has been used, which consists of cutting a long slot in each fragment, about one-fourth inch in diameter, into which the dense outer portion

1. A preliminary report was published some time ago (Campbell, W. C.: Treatment of Ununited Fractures, Am. J. Surg. **37**:1 [Jan.] 1923).

of the massive graft is inserted across the line of fracture. After about eight holes have been drilled, bone nails are driven through the shaft of bone and graft. By these measures, stabilization has been so complete that no motion between fragments can be detected. Nevertheless, external fixation is always applied.

In order to carry out this tedious procedure, the assistance of a team of trained associates is essential, as well as the most rigid instrumental technic. It is not a one man operation. One surgeon, with two associates, prepares the fracture, while the second and one assistant remove the graft and prepare the nails. Otherwise too much time would be consumed.

External fixation remains for eight weeks. Further observation might materially shorten this period. For six months some form of light brace, commensurate with joint function, is worn, as experience has shown that all bone grafts require protection over a long period of time.

Within the past two years we have gradually discarded other procedures, and we are now employing this method in all cases. In seventeen cases sufficient length of time has elapsed to justify giving results. All of the fractures were apparently united on removal of splint or cast. No motion could be detected between fragments; and there have been no cases of nonunion. The time required for union has been materially shortened. In one case, only five weeks was required. No infections or other complications have occurred. The distribution was as follows: femur, three; humerus, seven; both bones of the forearm, three; ulna, one; radius, one; jaw, one; tibia, one. The most difficult fracture is that involving both bones of the forearm and the upper third of the femur.

CONCLUSION

1. Reduction of fractures should be accomplished with minimum trauma to the soft parts, and without numerous attempts.

2. In open reductions of fresh fracture, which is seldom necessary, care should be taken not to destroy or inhibit natural osteogenetic elements.

3. In operation for ununited fractures, as small an area of periosteum as possible should be disconnected from the bone, leaving attached muscles and soft tissues from which nutrition is derived through the blood stream.

4. With internal fixation and osteogenesis, the results have been all that could be desired; and the time of consolidation has been materially lessened, and function has been thereby conserved, by earlier active motion. In consequence, I believe the technic described is of material value and worthy of consideration at the present time.

GASTRIC ULCER STUDIES *

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AND
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I. THE RESISTANCE OF VARIOUS TISSUES TO GASTRIC DIGESTION

The question "Why does not the stomach digest itself?" is of recurring interest to both the biologist and the physician. It is probable that the explanation for the resistance offered by the normal gastric mucosa to the digestant action of pepsin-hydrochloric acid will be of great significance in determining the etiology of gastric and duodenal ulcers. From the time of Virchow it has been the common belief that these lesions are determined by a loss of resistance on the part of the mucosa to gastric digestion; hence the term peptic ulcer.

Despite the number of explanations that have been offered from time to time to account for the nondigestion of the normal gastric mucosa, the essential question remains unanswered. Hunter [1] believed that all living uninjured cells could resist the digestant action of gastric juice, a statement that at the present time seems to be at least partially true. It was early discovered that the resistance of the stomach wall to gastric digestion disappeared on the death of the animal. If an animal was killed during the height of digestion and was kept warm, the gastric juice would digest its way through the stomach wall, such digestion beginning before the cells of the mucosa or muscularis were dead. Varying degrees of digestion of the gastric mucosa or esophagus (esophagomalacia) were the common observation of all pathologists.

Claude Bernard [2] discovered that the leg of a living frog would be digested away if introduced through a fistula into the stomach of a dog. Pavy [3] found the same to be true if a rabbit's ear was similarly exposed to dog's gastric juice in vivo. He believed that the alkalinity of the blood in the gastric tubules prevented digestion, through a neutralization of the hydrochloric acid of the gastric juice.

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* From the Hull Physiological Laboratories of the University of Chicago and the Division of Physiology and Pharmacology of Northwestern University Medical School.

* A demonstration of these experiments was made at a meeting of the American Physiological Society, Toronto, December, 1922.

1. Hunter: Philosophical Transactions, 1772, p. 450.
2. Bernard, Claude: Bailliere Legons de physiol. experiment, Paris, 1859.
3. Pavy: Cited by Rost, Franz: Pathological Physiology of Surgical Diseases, Philadelphia, P. Blakiston's Son and Company, 1923.

Katzenstein [4] transplanted sections of spleen, intestine and omentum into the stomach and found that they were promptly digested. The transplanted stomach wall was however not affected. Later, he [5] and Kathe [6] isolated loops of intestine in dogs and transplanted them in the stomach. The mesenteric blood supply to these isolated loops was not interfered with in any way. They found that the intestinal mucosa had no resistance to the digestive power of the gastric juice and was completely dissolved in a short time. Sections of gastric mucosa reimplanted in the stomach showed a much greater resistance. Katzenstein concluded that the gastric mucosa contained an antienzyme not present in the intestinal mucosa. This theory was suggested by the discovery by Weinland [7] of substances in the bodies of intestinal parasites and in the gastric mucosa which seemed to inhibit the activity of pepsin-hydrochloric acid. These substances were called antienzymes.

Matthes thought that he had proved that the stomach mucosa had a special resistance to hydrochloric acid not shared by other tissues. It is a common observation that gastric juice flowing over the normal skin produces extensive corrosion both in man and in dogs. According to Matthes, the cells are first killed by the acid and then subsequently digested by the pepsin-hydrochloric acid. The question would then become "Why does not the hydrochloric acid first injure the gastric mucosa and then digest it?"

Roux and Riva [8] and Klug [9] suggested that a protective covering of the gastric mucus was the important factor in the resistance of the cells to gastric juice.

Licini [10] and Hotz [11] found that when great care was taken not to injure the blood supply, the spleen and loops of the intestine could be implanted in the stomach without undergoing digestion. Tietze [12] found that omentum sutured in an injured gastric wall would not be digested away. Best,[13] who repeated these experiments, came to directly the opposite conclusion. This work was not known to us when our experiments were performed.

It has been suggested by Stewart [14] that the various body membranes may have developed a specific resistance to the fluids with which

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4. Katzenstein, M.: Berl. klin. Wchnschr. **45**:1749, 1908.
5. Katzenstein, M.: Berl. klin. Wchnschr. **45**:1751, 1908.
6. Kathe, H.: Berl. klin. Wchnschr. **48**:2135, 1908.
7. Weinland: Ztschr. f. Biol. **43**:86; **44**:1, 1902.
8. Roux, J. C., and Riva, A.: Compt. rend. Soc. Biol., Paris **60**:537, 1906.
9. Klug: Arch. int. de physiol. **5**:297, 1907.
10. Licini, C.: Beitr. z. klin. chir. **82**:377, 1912.
11. Hotz, G.: Mitt. a. d. Grenzgeb. d. Med. u. Chir. **21**:143, 1910.
12. Tietze, A.: Beitr. z. klin. chir. **25**:411, 1900.
13. Best: Beitr. z. path. Anat. u. z. allg. Path., Jena **60**:170, 1914.
14. Stewart, G. N.: Manual of Physiology, New York, William Wood & Co., 1921, p. 389.

they normally come in contact, but not to other juices. This is an elaboration of the idea of Matthes; namely, that the gastric mucosa had developed a special resistance to hydrochloric acid which he claimed was destructive to other cells. Thus, the mucosa of the stomach has developed a protective mechanism against pepsin-hydrochloric, the intestinal mucosa against the alkaline pancreatic juice and succus entericus, the endothelium of the blood vessels against the blood plasma, etc. To obtain evidence on this question, experiments were devised so that the mucous membranes of the duodenum, jejunum, ileum and colon were exposed to gastric digestion under conditions comparable to that obtaining for the gastric mucosa. Experiments of this kind have been reported by others, but they were repeated for confirmation and extended. Mann [15] transplanted loops of the jejunum in the posterior wall of the stomach. The jejunal mucosa remained normal, but was digested on subsequent extirpation of the suprarenals. He [16] is inclined to the view that if such transplants are made into the pyloric region of the stomach instead of the fundus, they will be digested.

Resistance of Intestinal Mucosa to Gastric Digestion.—Healthy adult dogs were operated on in the following manner: A large opening or window (4 by 10 cm.) was made in the anterior wall of the stomach, midway between the greater and lesser curvatures. The opening extended to within 1 inch (2.5 cm.) of the pylorus. This window was then filled up by an intestinal flap taken from various parts of the intestines, prepared thus: The intestine was cut across in two places about 12 cm. apart, and the isolated segment with its mesenteric blood supply intact set aside. The continuity of the intestinal tract was reestablished by end to end anastomosis. The isolated segment was then opened by an incision extending the length of the antimesenteric border. The flap thus produced was carefully stitched into the opening in the stomach, forming in this way a part of the gastric wall. Special care was taken not to injure the blood supply to the intestinal segment.

In three experiments, the mucosa of the lower duodenum, the upper jejunum, the ileum and the colon were exposed to gastric digestion by the method described above. The animals were subsequently opened at intervals ranging from one to twelve months, but in no case was there any evidence of digestion of the transplant. After twelve months, exposure to the gastric juice, the intestinal mucosa was still distinct and could be readily differentiated from the gastric mucous membrane. It was entirely normal both on microscopic and on macroscopic examination. Such positive findings would seem to disprove negative results,

15. Mann, F. C.: J. Exper. Med. **23**:203 (Feb.); **24**:329 (Oct.) 1916.
16. Mann, F. C.: Personal communication.

especially since it would be always difficult to be sure that the digestion of the transplant obtained was not made possible by an injury during the surgical manipulations.

Resistance of Intestinal Serosa to Gastric Digestion.—The finding that the normal mucous membrane of the entire gastro-intestinal tract could resist gastric digestion raised the question whether that resistance was a property only of mucous membranes. To test this possibility, the following experiments were made: A window was made in the stomach as before, and closed by suturing a loop of intestine into the opening. The serosa was thus exposed to the digestant action of the gastric juice. After from one to two months, the animals were killed and the stomachs examined. In all three experiments, there was a smooth, round opening between the stomach and intestine. In one case, a bridge of mucous membrane persisted and had successfully withstood digestion. It would appear that the intestinal serosa and muscular layers are not so resistant as the mucosa. The experiment is subject to the objection that a portion, at least, of the blood supply to the area of intestine exposed to the gastric juice had been interfered with by the sutures introduced.

Resistance of the Spleen to Gastric Digestion.—Advantage was taken of the findings described above to determine the effect of gastric digestion on the spleen. Openings were made in the stomach as before and the spleen was carefully sutured into the stomach wall, care being taken not to interfere with the splenic blood supply. Animals so operated on were examined later at intervals ranging from two weeks to three months, and in no case was there evidence of digestion of the splenic capsule.

This surprising finding, which demonstrated that the capsule of the spleen could resist indefinitely full strength active gastric juice, led to experiments with the splenic pulp itself. The capsule was removed by cutting a deep groove in the spleen and implanting the denuded area in the stomach so that it would be acted on by the gastric juice. Bleeding was first checked by the application of hot sponges. Previous tests had disclosed that the gastric secretion was normal. These animals were in good condition after the operation and displayed no subsequent ill-effects. They were later killed at periods ranging from two weeks to three months, and the stomachs were removed for examination. Although the splenic pulp had been widely exposed, there was no digestion apparent on macroscopic observation (Fig. 1).

Microscopic examination revealed many interesting changes in the exposed tissue. There was no membrane of cellular débris covering the spleen, as might have been expected, but the splenic pulp was directly exposed. There was a relative connective tissue fibrosis in the exposed

region, but many normal appearing cells of the splenic pulp were present. There was a preponderance of eosinophilic lymphoid cells in the exposed area. At both edges of the spleen implant could be seen a single layer of columnar epithelial cells growing out from the stomach to cover the implant (Fig. 2). Stains with fuchsin and muchematein (Fig. 3) to show mucus indicated that this layer of cells all contained mucus, but that there was no mucus covering the exposed spleen. Great care had been taken not to disturb the exposed surface in preparing the specimen, so it seems quite certain that a protective covering of mucus does not explain the failure of digestion of the spleen. This is an important point since it rules out all theories of resistance which depend on some protective envelop and which do not take into account a resistance of the naked exposed cell.

Fig. 1.—Implantation of the spleen in a window made in the anterior wall of the stomach, with exposure to gastric digestion for two weeks. The capsule of the spleen was removed before implantation so that the gastric juice had direct access to the splenic pulp. The blood supply to the spleen was not interfered with. The spleen was not digested, although tests indicated that the gastric juice was normal.

Resistance of the Kidney to Gastric Digestion.—The left kidney was mobilized by removing the perirenal fat, and was implanted in the anterior wall of the stomach, as in the case of the spleen. Three experiments of this kind were performed and the animals were killed after two weeks, one month and two months, respectively. In no case was there any evidence of digestion of the kidney capsule.

In order to expose the kidney parenchyma to gastric digestion, a groove was cut in the kidney before it was implanted in the stomach.

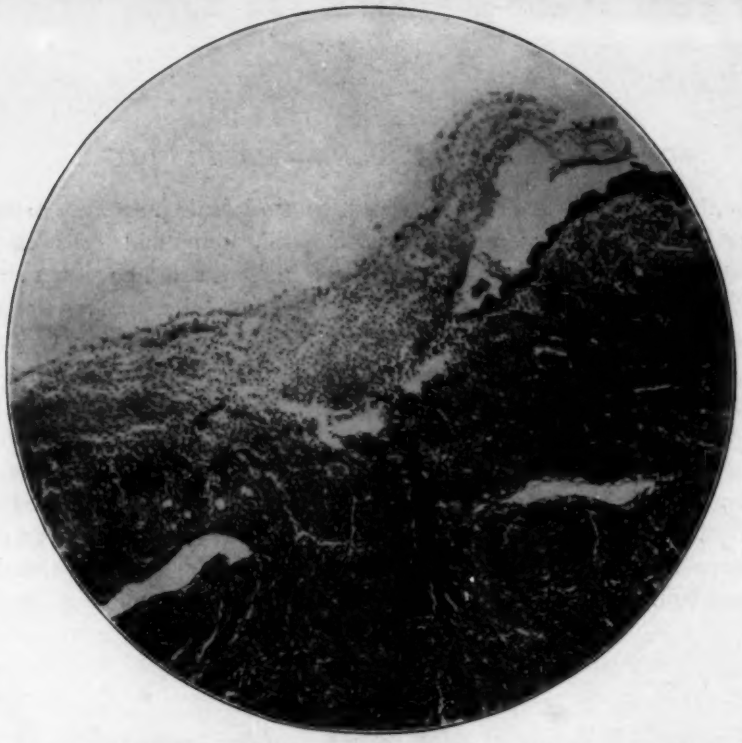

Fig. 2.—Section taken near the edge of the spleen implant in the stomach (×65). At the right, a single layer of epithelial cells may be seen growing out from the stomach over the exposed spleen pulp. To the left is shown the splenic tissue exposed to the digestant action of the gastric juice. This is the specimen shown in Figure 1.

Fig. 3.—Section shown in Figure 2, stained with fuchsin and muchematein to show mucus. The slide shows that whereas there is abundant mucus in the cells growing out over the edge of the implant, there is none in the more advanced cells and none covering the exposed splenic pulp.

Fig. 4.—Implantation of the kidney in a window made in the anterior wall of the stomach, with exposure to gastric digestion for seventeen days. The capsule of the kidney was first removed so that gastric juice had direct access to the kidney parenchyma. The blood supply to the kidney was not interfered with. There was no digestion of the exposed kidney parenchyma.

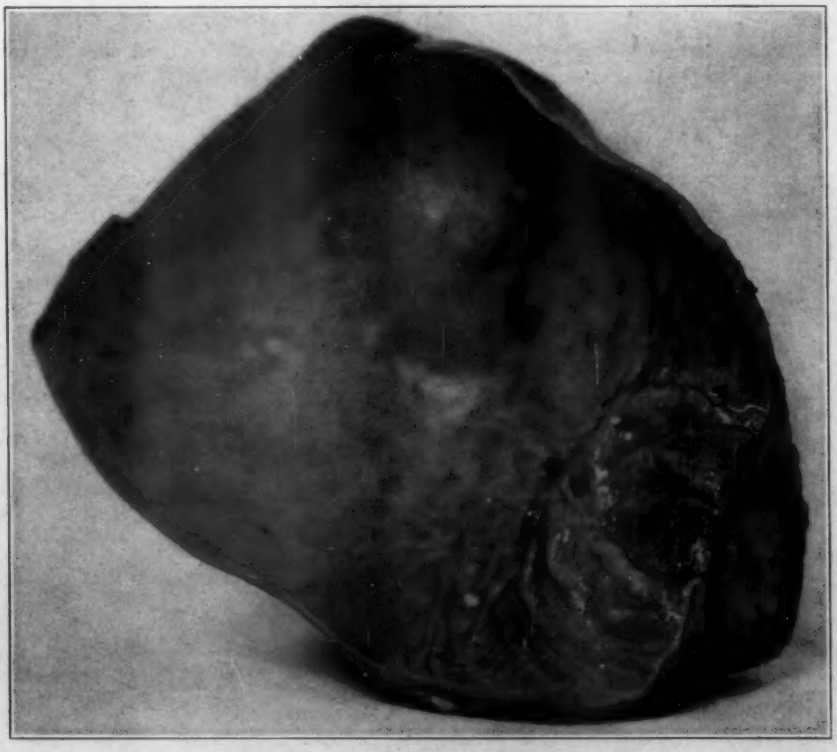

Fig. 5.—Specimen shown in Figure 4. The kidney has been cut to show the absence of digestion of the kidney substance.

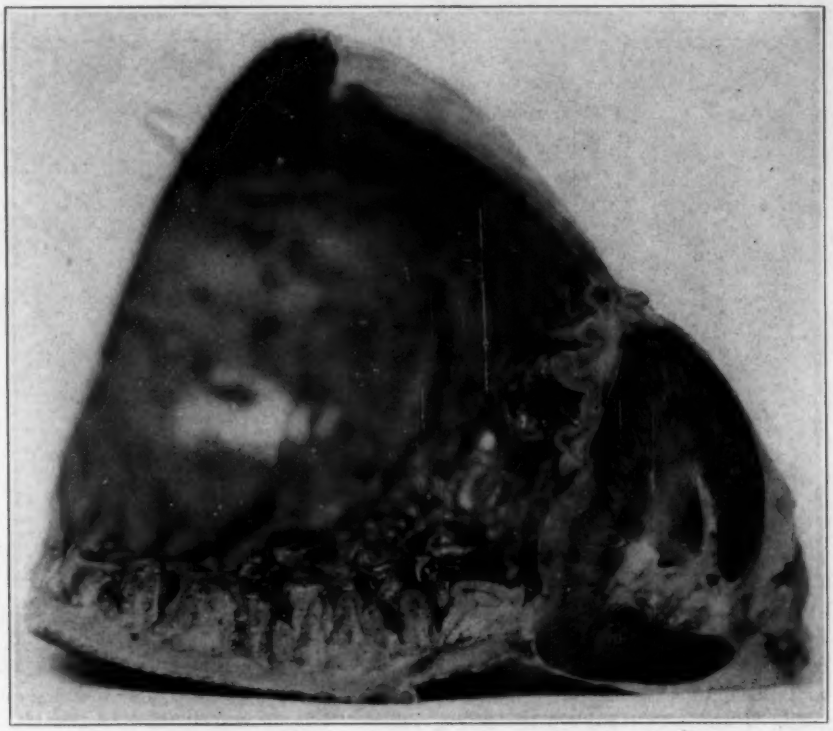

Fig. 6.—Implantation of the kidney in a window made in the anterior wall of the stomach, with exposure to gastric digestion for fourteen days. The capsule of the kidney was first removed so that the gastric juice had direct access to the kidney parenchyma. The blood supply to the kidney was not interfered with. Although tests demonstrated that the gastric juice was normal in acid and pepsin content, there was no digestion of the exposed kidney.

Fig. 7.—Section taken through the implant of the decapsulated kidney in the stomach (×6). The kidney cortex that had been exposed to gastric digestion shows surprisingly little alteration and the markings can easily be seen.

Fig. 8.—Section taken to show the surface of the kidney implant that had been exposed to gastric digestion (×65). The marked fibrosis and leukocytic infiltration can be readily seen. Although in this case the kidney cortex had been exposed to gastric digestion for two weeks, the remains of a glomerulus can be made out on the exposed surface, while several glomeruli not more than a millimeter below the surface are but little affected.

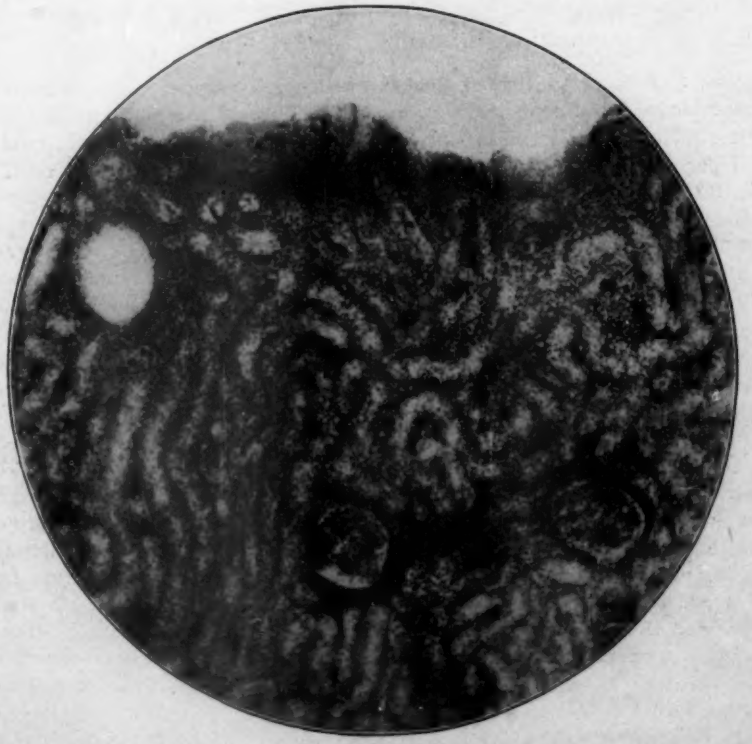

Fig. 9.—Section taken to show the surface of a kidney implant that had been exposed to gastric digestion for seventeen days (×65). The exposed edge is necrotic and there is a marked leukocytic infiltration of the neighboring tubules.

The parenchyma of the cortex was thus exposed. Three experiments of this kind were performed and the stomachs were removed for examination after two to four weeks. Although previous tests had demonstrated that the gastric secretion was normal, to our surprise there was no macroscopic evidence of digestion of the exposed kidney parenchyma (Figs. 4, 5 and 6).

Microscopic examination of the exposed kidney surface revealed a marked accumulation of leukocytes and a connective tissue proliferation extending about 5 mm. into the kidney substance (Figs. 7 and 8). In several areas, the glomeruli had been directly exposed with surprisingly little injury. This was also true of the tubular epithelium.

Digestion of Frog's Leg by Gastric Juice (Dog and Human) in Vitro.—The observation of Claude Bernard that the leg of a living frog will be digested if placed through a fistula in a dog's stomach may be easily confirmed. The following in vitro experiments confirm and amplify that early observation in a striking way.

A number of test tubes partly filled with gastric juice of varying acidity were closed at the top with rubber dams. These were perforated so that they would fit loosely about the hind leg of a frog. In each case one hind leg was ligated to completely occlude its blood supply. The front legs were tied together to minimize movement and each hind leg introduced into a test tube so that the leg was well immersed in the digestant liquid. Digestion was allowed to proceed in the incubator at 37 C., the animals being removed from time to time for observation. The following is a typical experiment:

Nov. 4, 1921. Digestion experiment with dog's gastric juice: Tubes 1 and 2 contained 0.4 per cent. hydrochloric acid; Tubes 3 and 4, neutralized active gastric juice; Tubes 5 and 6, gastric juice (free acid, 0.356 per cent., total acid, 0.439 per cent.); Tubes 7 and 8, gastric juice (free acid, 0.136 per cent., total acid, 0.221 per cent.); Tubes 9 and 10, gastric juice (free acid, 0.064 per cent., total acid, 0.108 per cent.); Tubes 11 and 12, Ringer's solution.

Tubes 13 and 14 contained the pancreatic juice of a dog (0.3 per cent. alkalinity). The frog's legs exposed in Tubes 1, 2, 3, 4, 11 and 12 appeared entirely normal even after eight hours' exposure. There was no digestion. The legs exposed to pancreatic juice (Tubes 13 and 14) showed no digestion after eight hours, but the skin was softened and a gelatinous material came away. In all of the experiments in which the frogs' legs were exposed to gastric juice containing free hydrochloric acid, there was marked digestion evident while the animal was still living. The extent of digestion was directly proportional to the acid concentration of the gastric juice, being greatest in Tubes 5 and 6 and least in Tubes 9 and 10. In general, the digestion of the ligated leg was greater than that of the other whose circulation was intact. The course of the digestion could be directly observed. In Tubes 5 and 6, the skin became edematous and friable and was digested away in places at the end of the first hour. During the second hour, all of the skin was digested and portions of the fascia attacked. At the end of five hours, the muscles and fascia were almost entirely dissolved, leaving a network of blood vessels surrounding the bone. The apparent resis-

tance of even the finer blood vessels was striking. This resistance was due to the circulating blood, since it was not seen in the leg, the vessels of which had been previously ligated. Ultimately, however, one of the finer vessels gave way, a fatal hemorrhage ensuing.

Digestion of a Frog's Leg by Frog's Gastric Juice in Vitro.—The preceding experiments demonstrated that the living frog's leg may be digested away by the normal gastric juice of man and of the dog. The normal gastric juice of the dog does not, however, digest away its own tissues, such as those of the parenchyma of the spleen and kidney, which cannot be considered to have developed any special resistance because of long and continuous contact. Apparently, the tissues of the frog's leg lack some property possessed by the dog's organs.

To secure evidence on this point, experiments were performed in which the frog's leg was exposed to the digestant action of frog's gastric juice, under conditions similar to those in which dog's gastric juice produced digestion. The gastric mucosa from a number of frogs was obtained and extracted with 0.4 per cent. hydrochloric acid. The artificial gastric juice thus produced was demonstrated to possess strong proteolytic activity (the experiment was performed during the summer months). Frogs of the same species were subjected to the digestant action of this juice at room temperature. In two hours, the skin of the exposed leg had been entirely digested away, and after four hours there was also considerable digestion of the muscle and connective tissues. The experiment is subject to the objection that the acidity of the artificial juice was perhaps higher than would be found in the normal secretion of the frog.

COMMENT

The demonstration that the normal mucous membrane of the duodenum, jejunum, ileum and colon can resist gastric digestion for months, with no demonstrable pathologic alteration, indicates that the immunity of these tissues is general rather than specific, and is not limited to the gastric mucosa. Within the range of acidity normal to the gastric secretion, the mucous membranes of the intestines are just as resistant to hydrochloric acid as is that of the stomach. The application of acids in greater concentration than could ever be present in the gastric juice can have no significance in this general problem. The evident resistance of the jejunal mucosa to the digestant action of pepsin-hydrochloric acid makes it necessary to look for additional factors in the etiology of jejunal ulcers following gastro-enterostomy. Furthermore, the fact that the capsule of the kidney or of the spleen, and even the parenchyma of these organs, resist gastric digestion when their nutrition is normal indicates that such resistance is far more general than was formerly supposed and that the mechanism of this resistance does not necessarily reside in some anatomic or physiologic property peculiar to mucous membranes. Hunter's statement that all living uninjured cells can resist

digestion is in part verified. This fact has considerable significance as regards the mechanism of formation of hydrochloric acid by the gastric glands. The argument that hydrochloric acid is manufactured in some combined form in the cell and only appears as free acid after it reaches the gastric cavity or lumen of the duct, because free hydrochloric acid would destroy the cell, loses weight in view of these new facts. It seems highly improbable that a local production of mucus is the important protective mechanism. The kidney and spleen parenchyma do not secrete mucus, and the special stains proved there was no layer of this substance covering the exposed tissues. If the resistance be due to an antienzyme, this must be widespread, and is not specific to the alimentary tract. Furthermore, it must be effective only so long as the blood supply to the tissues is normal.

The digestion of a frog's leg or a rabbit's ear by gastric juice in vitro or when introduced into a dog's stomach by way of a fistula is difficult to harmonize with the facts obtained from transplanting tissues in the stomach. It seems certain that the epidermis does not resist gastric digestion as do the other tissues described. This is probably due to its relatively poor blood supply. On the other hand, the fibrous tissue making up the capsule of the spleen or of the kidney would seem to be only a little, if any, more vascular.

The demonstration that the frog's leg may be digested by frog's gastric juice indicates that this destruction is not due to a foreign or heterologous digestive fluid, but can be accomplished by the animal's own enzymes.

Activated gastric juice, in which the hydrochloric acid had been neutralized, had no digestant action on the frog's leg. The active pepsin is thus not the important destructive factor. It seems probable that, in this experiment, the explanation of Matthes is probably correct; namely, that the acid must first kill the tissue, and this is then dissolved by the pepsin-hydrochloric acid. This would account for the greater corrosive effect of the more acid mixtures.

The finding of a layer of epithelial cells growing out from the gastric mucosa to cover the exposed spleen parenchyma (Figs. 2 and 3) indicates that the immature growing cells of the gastric mucosa have quite as much resistance to gastric corrosion as does the adult mucosa. It is quite evident that the gastric juice does not prevent such a healing process when the cells are normal.

II. A METHOD FOR PRODUCING CHRONIC GASTRIC ULCERS IN DOGS

One of the principal difficulties in the study of the various problems associated with gastric and duodenal ulcer has always been the great difficulty of producing such lesions in experimental animals. Almost

every conceivable method for producing acute lesions in the gastric mucosa has been tried repeatedly, but the common experience has been that such lesions do not become chronic ulcers. Several years ago, one of us [17] attempted to produce ulcers in the stomach of dogs by injecting beneath the mucosa a solution of silver nitrate. The acute lesions thus produced healed quite as readily when subjected to the continuous action of the pepsin-hydrochloric acid of the gastric juice as they did when protected from such digestant action. The discovery that the parenchyma of the normal kidney can resist gastric digestion, however, makes it less surprising that the gastric juice did not destroy the tissues of the gastric wall from which the mucosa had been removed. Ivy [18] had demonstrated the importance of cachexia as a factor in inducing experimental ulcers in dogs. Mann [19] produced ulcers in the small intestine of dogs by various surgical procedures devised to expose the intestinal mucosa to gastric digestion.

The occasional occurrence of ulcers in the region of gastroenterostomy openings (gastrojejunal ulcers), and the statement that such lesions are most common when nonabsorbable suture material is used, suggested a method for producing experimental ulcers in dogs, which has been far more successful than any other method that we have used. The procedure is as follows. An incision is made through the anterior wall of the stomach near the pylorus. The mucosa of the posterior wall is secured and pulled out through the opening. A solution of 4 per cent. silver nitrate is then injected beneath the mucosa forming a circular cauterized area about 3 cm. in diameter. From twenty to thirty sutures of heavy linen thread are then placed in this area, extending deeply into the muscularis and tied loosely so that the cut ends may extend into the cavity of the stomach. The necrotic area soon sloughs away, leaving a circular lesion whose healing is delayed by the presence of the unabsorbed sutures. Of six dogs operated on by this method, four showed unhealed lesions three and four months after the production. This is a higher percentage of chronicity than can be obtained by other methods which do not involve systemic disturbances, such as anemia or cachexia.

The fact that chronic lesions can be produced by this method in such a high percentage of cases illustrates the danger of leaving nonabsorbable suture material extending through the mucosa. It is also suggestive as regards the etiology of certain of the gastrojejunal ulcers.

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17. Dragstedt, L. R.: Ulcer, J. A. M. A. **68**:330 (Feb. 3) 1917.

18. Ivy, A. C.: Physiology of Stomach: Studies on Gastric Ulcer, Arch. Int. Med. **25**:6 (Jan.) 1920.

19. Mann, F. C.: Personal communication.

III. THE EFFECT OF ADMINISTRATION OF ALKALIS ON THE HEALING OF EXPERIMENTAL ULCERS IN DOGS

The medical management of gastric and duodenal ulcers that is most widely adopted and has apparently given the best results is based upon the conception that the chief factor which prevents the healing of such lesions is the digestant action of the gastric juice. This may be controlled by a complete and continuous neutralization of the gastric content by a strict dietary regimen and the administration of alkalis. While there can be no doubt that many, perhaps most, ulcers tend to heal under such management the results are not so uniform as the reasoning might lead one to expect. In particular, it has been difficult to demonstrate that active gastric juice of even high free acidity has any significant retarding effect on the healing of traumatic ulcers in experimental animals. Some workers [20] have apparently induced chronicity in such lesions, by feeding hydrochloric acid with the food; but the strength of acid required to delay healing appreciably has been far in excess of that normally present.

The development of a method for producing localized gastric lesions, which in a majority of animals become chronic ulcers, affords a ready opportunity for determining the effect of alkali administration on the healing process.

Experimental Procedure.—Lesions were produced on the posterior wall of the stomach in two groups of dogs. The method was the same as that described in the preceding chapter for the production of chronic gastric ulcers. An effort was made to secure lesions of the same size and in the same part of the stomach in both groups. One group of animals was given the usual stock laboratory diet of bread, meat and vegetables. The second group was given the same diet plus sufficient alkalis to neutralize the hydrochloric acid in the gastric secretion continuously during the twenty-four hours. The administration of the alkalis definitely promoted the healing of these lesions as compared with those in the control animals.

PROTOCOLS

GROUP 1.—Controls. Lesions were produced in the pyloric antrum on the posterior wall near the lesser curvature of the stomach in ten dogs. The technic for the production of these lesions has been described in the preceding chapter. Care was taken to produce lesions of the same size and extent in each case. These animals were given bread, meat and vegetables, but no medication. They were killed at varying intervals, and the lesions were examined.

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20. Bolton: J. Pathol. & Bacteriol. **20**:133, 1915. Matthes: Beitr. z. path. Anat. u. z. allg. Path., Jena **13**:309, 1893.

Dog 1 was killed twenty-five days after production of the lesion.

The sutures were present. There was a perforating ulcer (3 by 1.5 cm.) about 6 cm. from the pylorus on the posterior wall. A plug of omentum had filled the perforation. Microscopically, the mucosa over a considerable area was eroded leaving the muscular layer exposed.

Dog 2 was killed fifty-nine days after production of the lesion. The sutures were present. There was marked proliferation of the mucosa at site of lesion, with a small area in which the muscularis was bared.

Dog 3 was killed seventy-four days after production of the lesion. The sutures were gone. There was complete healing with no evidence of an ulcer.

Dog 4 was killed seventy-six days after production of the lesion. The sutures were gone. There was complete healing with no evidence of ulcer.

Dog 5 was killed ninety days after production of the lesion. The sutures were present. There was a definite circular ulcer at the site of the lesion (1 cm. in diameter), with marked proliferation and thickening at the periphery.

Dog. 6 was killed 105 days after production of the lesion. The sutures were present. There was a definite circular ulcer (1 cm. in diameter) at the site of the lesion.

Dog 7 was killed six days after production of the lesion. The sutures were present. There was a large defect in the mucosa (3 cm. in diameter) very hyperemic and with no evidence of healing.

Dog 8 was killed fourteen days after production of the lesion. The sutures were present. There was a large defect in the mucosa (2 cm. in diameter), with inflamed and hyperemic edges and no evidence of healing.

Dog 9 was killed twenty-one days after production of the lesion. The sutures were present. The lesion was entirely healed.

Dog 10 was killed twenty-six days after production of the lesion. The sutures were present. There were three small ulcers (each about 0.5 cm. in diameter) at site of lesion, with marked proliferation of the mucosa.

GROUP 2.—Dogs treated with alkalis. In all of these animals, lesions were produced similar in size, extent and location to those in the control animals. The diet was the same. The first four dogs were given alkalis by stomach tube every three hours during the day (6 a. m. to 11 p. m.) The mixture administered consisted of 2 gm. of sodium bicarbonate and 2 gm. of magnesium oxid in 100 c.c. of water. This amount was found sufficient to afford a complete and continuous neutralization of the gastric juice. The remaining seven dogs were given 10 gm. of a mixture of equal parts of sodium bicarbonate, calcium carbonate and magnesium oxid, daily, in gelatin capsules. This was also found adequate for continuous neutralization of the gastric content. The capsules were given at three-hour intervals during the day.

Dog 11 was killed twenty-nine days after production of the lesion. The sutures were gone, and the lesion had healed completely.

Dog 12 was killed seventy days after production of the lesion. The sutures were gone; the lesion was healed.

Dog 13 was killed seventy-seven days after production of the lesion. The sutures were gone. Lesion healed.

Dog 14 was killed ninety-nine days after production of the lesion. The sutures were gone; the lesion was healed.

Dog 15 was killed seven days after production of the lesion. The sutures were present. There was a large circular defect in the mucosa at the site of the lesion. There was distinctly more healing in this lesion than in Dog 7.

Dog 16 was killed fourteen days after production of the lesion. The sutures were present. There was a large circular defect in the mucosa at the site of the lesion. The edges were inflamed and hyperemic.

Dog 17 was killed twenty-two days after production of the lesion. The sutures were present. There was marked proliferation of the mucosa but no ulcer.

Dog 18 was killed thirty-three days after production of the lesion. The sutures were present. There was marked proliferation of the mucosa but no ulcer.

Dog 19 was killed thirty-eight days after production of the lesion. The sutures were present. There was a small ulcer (1 cm. in diameter) present with greatly thickened edges.

Dog 20 was killed forty-two days after production of the lesion. The sutures were present; the lesion was completely healed.

Dog 21 was killed fifty days after production of the lesion. The sutures were present. There was a small ulcer (0.5 cm. in diameter) at the site of the lesion.

COMMENT

It is obvious that the primary exciting factor in these experimental ulcers is not the same as in clinical ulcers in man. The initial cause of the lesion was the destructive action of the silver nitrate on the mucous membrane, and the acute lesion formed failed to heal chiefly because of the persistent irritant effect of the nonabsorbable sutures. The experiments indicate that the administration of alkalis in amounts sufficient to neutralize the gastric secretion definitely promotes the healing of these lesions. It does not necessarily follow that free acid in the gastric juice has been the factor which delayed healing, since it is well known that alkalis under these conditions do more than merely neutralize the gastric juice. They decrease the gastric tonus and bring about at least a partial immobilization of the pylorus. It is probable that this effect of the alkalis on gastric motility may be as important as, if not more important than, the effect on gastric acidity in the alkali therapy of gastric and duodenal ulcer. This is especially evident in the present medical managements of clinical ulcer cases by the use of special bland diets and alkalis, such as the method perfected by B. W. Sippy. It is probable that a medical management of gastric ulcer, based upon the conception that the motility of the stomach and pylorus was the chief factor in delaying healing and promoting chronicity, would not be much different from the present treatments which are directed toward combating the digestant action of the pepsin-hydrochloric acid.

IV. THE CAUSE OF HYPERSECRETION OF GASTRIC JUICE IN EXPERIMENTAL GASTRIC ULCER

There is no other gastric disease in which the physician so frequently finds, on aspiration of the Ewald's meal, acid values as high as in gastric or duodenal ulcer. A high percentage of ulcer patients show a free acid

titration of more than 40 units and a total acidity of more than 60. This has been commonly, but erroneously, called hyperacidity. Carlson [21] has repeatedly pointed out that normal pure undiluted human gastric juice shows a free acidity of from 110 to 140 units and a total acidity of from 125 to 165 units. The concentration of hydrochloric acid in the gastric content of ulcer patients rarely reaches that of normal pure gastric juice. A hypersecretion of gastric juice has been found, however, in a large proportion of stomach ulcers, both with and without an associated pyloric obstruction. It is not a constant accompaniment, and a considerable number of cases show both a decreased secretion and varying degrees of hypo-acidity to complete anacidity.

Some observers (Hurst [22]) have postulated an etiologic relation between the hypersecretion and the ulcer; namely, that individuals with gastric hypersecretion are more liable to ulcers than those with normal secretion. Here, it is assumed, of course, that the hypersecretion has preceded the ulcer and is brought about by some other cause. On the other hand, there is a good deal of indirect evidence indicating that the ulcer may cause the hypersecretion. The question would have been settled long ago if surgeons who excised ulcers had followed the gastric secretion in their patients after the operation. Some such observations have been made, and they indicate that the secretion rate diminishes after the excision.

The development of a method for producing chronic gastric lesions in dogs with a fair degree of certainty made it possible to test the effect of such lesions on the gastric secretion when the normal secretion could be accurately determined beforehand. Hardt,[23] who had previously made such studies by a different method, concluded that gastric or duodenal ulcers may or may not induce an increase in the gastric secretion of digestion and the continuous secretion.

Five adult female dogs were provided with Pawlow accessory stomach pouches for the collection of the pure gastric secretion. After the normal secretory response to a constant test meal had been determined, ulcers were produced in the pyloric region of the stomach after the method described in the preceding papers. The results given in detail in the tables indicate that the ulcers caused a small but definite increase in the rate of secretion and in the acidity of the juice. In no case, however, was the concentration of hydrochloric acid higher than may be observed in the normal pure gastric secretion of dogs; i. e., a hyperacidity was not produced. Animals with a marked hypo-acidity were chosen for the experiments since a stimulating action of the lesion would be more apparent in these than in normal dogs.

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21. Carlson, A. J.: Physiol. Rev. **3**:1 (Jan.) 1923.
22. Hurst, A. F.: Brit. M. J. **1**:559 (April 24) 1920.
23. Hardt, L. L. J.: A. J. Physiol. **40**:314 (April) 1916.

TABLE 1.—*Experimental Data (Dog 1)**

Date	Quantity, C.c.	Free Acid, per Cent.	Total Acid, per Cent.
3/28	2.0	0.045	0.13
3/29	4.2	0.045	0.13
3/30	4.0	0.00	0.15
3/31	3.2	0.04	0.12
4/ 1	4.1	0.00	0.15
4/ 2	6.4	0.00	0.15
4/ 3	3.8	0.05	0.15
4/ 4	3.8	0.05	0.15
4/ 5	2.0	0.00	0.05
4/ 6	2.0	0.00	0.05
4/ 7	2.0	0.00	0.05
4/ 8	1.9	0.00	0.05
4/ 9	1.2	0.00	0.05
4/10	1.2	0.00	0.05
4/11	3.0	0.00	0.05
4/12	4.5	0.00	0.09
4/17	2.7	0.00	0.04
4/18	1.0	0.00	0.03
Average	2.95	0.018	0.091
4/19 †			
4/20	1.4	0.00	0.02
4/21	2.8	0.00	0.03
4/22	1.3	0.00	0.03
4/23	5.5	0.04	0.15
4/24	4.0	0.05	0.17
4/25	2.5	0.00	0.06
4/26	5.0	0.06	0.17
4/27	2.8	0.00	0.03
4/28	4.0	0.04	0.10
4/29	3.2	0.00	0.06
4/30	2.1	0.00	0.05
5/ 1	2.0	0.00	0.04
5/ 2	1.5	0.00	0.03
5/ 3	5.0	0.00	0.08
5/ 4	2.5	0.00	0.03
5/ 5	1.0	0.00	0.03
5/ 6	1.5	0.00	0.04
5/ 7	2.5	0.00	0.03
Average	2.81	0.010	0.064

* A Pawlow accessory stomach pouch was made, March 10, 1921. The gastric secretion following a standard meal of 300 gm. of meat, 500 gm. of bread, and 500 c.c. of milk was determined for the two-hour period after eating.

† Lesion produced in the pyloric part of the stomach (entirely healed at necropsy).

TABLE 2.—*Experimental Data (Dog 2)**

Date	Quantity, C.c.	Free Acid, per Cent.	Total Acid, per Cent.
5/ 7	2.5	0.00	0.03
5/ 8	2.2	0.00	0.03
5/ 9	2.1	0.00	0.02
5/10	2.5	0.00	0.03
5/11	2.5	0.00	0.03
5/12	2.9	0.01	0.08
5/13	4.8	0.00	0.03
5/14	3.0	0.00	0.03
5/15	2.5	0.00	0.03
5/16	2.5	0.00	0.03
Average	2.75	0.00	0.03
5/17 †			
5/18	4.0	0.00	0.07
5/19	1.7	0.00	0.03
5/20	3.5	0.00	0.05
5/21	9.5	0.16	0.25
5/22	2.1	0.00	0.03
5/23	2.0	0.00	0.03
5/24	2.5	0.00	0.04
5/25	3.0	0.00	0.04
5/26	2.0	0.00	0.04
5/27	4.5	0.00	0.05
Average	3.4	0.02	0.06

* A Pawlow accessory stomach pouch was made May 7, 1921. The gastric secretion for the two-hour period following a standard test meal was determined.

† Lesion produced in pyloric part of stomach (present at necropsy).

TABLE 3.—*Experimental Data (Dog 3)**

Date	Quantity, C.c.	Free Acid, per Cent.	Total Acid, per Cent.
6/15	3.1	0.00	0.09
6/16	2.0	0.00	0.08
6/17	2.0	0.00	0.08
6/19	0.7	0.00	0.04
6/20	3.0	0.00	0.03
6/21	5.0	0.00	0.03
6/22	3.5	0.00	0.01
6/23	2.5	0.00	0.05
6/24	2.5	0.00	0.05
6/25	4.0	0.01	0.12
Average	2.83	0.00	0.058
6/27 †			
6/28	4.6	0.00	0.14
6/29	3.0	0.05	0.09
6/30	5.0	0.09	0.14
7/ 1	5.5	0.00	0.05
7/ 2	5.5	0.08	0.12
7/ 3	4.0	0.00	0.05
7/ 4	4.0	0.00	0.05
7/ 5	4.0	0.00	0.05
7/ 6	4.0	0.00	0.05
7/ 7	4.0	0.00	0.14
Average	4.36	0.03	0.088

* A Pawlow accessory pouch was made, June 6, 1921. The gastric secretion was determined as in preceding experiments.
† Lesion produced in pyloric part of stomach (present, July 8, 1921).

TABLE 4.—*Experimental Data (Dog 4)**

Date	Quantity, C.c.	Free Acid, per Cent.	Total Acid, per Cent.
4/23	8.2	0.00	0.00
4/24	15.0	0.00	0.09
4/25	11.8	0.08	0.19
4/26	3.9	0.00	0.05
4/27	9.0	0.04	0.18
4/28	3.8	0.00	0.06
4/29	7.5	0.00	0.02
4/30	4.3	0.10	0.20
5/ 1	1.8	0.00	0.05
5/ 2	9.0	0.10	0.19
Average	7.43	0.032	0.103
5/ 3 †			
5/ 4	4.5	0.00	0.07
5/ 5	3.5	0.00	0.04
5/ 6	4.0	0.15	0.26
5/ 7	8.5	0.21	0.31
5/ 8	5.5	0.02	0.06
5/ 9	5.6	0.05	0.12
5/10	8.7	0.02	0.09
5/11	15.5	0.32	0.42
5/12	3.9	0.04	0.11
5/13	12.0	0.22	0.32
Average	7.17	0.103	0.180

* A Pawlow pouch was made, April 6, 1921. The gastric secretion was determined as in preceding experiments.
† Lesion produced in the pyloric part of the stomach (present, May 14, 1921).

TABLE 5.—*Experimental Data (Dog 5)**

Date	Quantity, C.c.	Free Acid, per Cent.	Total Acid, per Cent.
7/ 5	9.5	0.00	0.05
7/ 6	6.5	0.00	0.04
7/ 7	2.0	0.04	0.10
7/10	6.0	0.00	0.14
7/11	2.0	0.00	0.04
7/12	6.0	0.00	0.14
7/17	4.0	0.05	0.16
7/18	4.0	0.00	0.09
7/19	4.0	0.00	0.09
7/20	8.0	0.00	0.05
Average	5.20	0.01	0.09
7/21 †			
7/22	2.5	0.09	0.15
7/23	1.0	0.02	0.09
7/24	2.6	0.06	0.14
7/25	2.5	0.04	0.09
7/27	14.0	0.03	0.04
7/28	2.0	0.00	0.03
8/ 1	5.0	0.00	0.07
8/ 2	8.5	0.04	0.09
8/ 3	9.0	0.09	0.12
8/ 4	9.0	0.07	0.11
Average	5.61	0.044	0.093

* A Pawlow pouch was made, April 8, 1921. The gastric secretion was determined as in preceding experiments.

† Lesion produced in the pyloric part of the stomach (present, Aug. 6, 1921).

COMMENT

The experimental evidence seems fairly conclusive that in dogs an experimental ulcer in the stomach may increase the secretion of gastric juice brought about during the digestion of a meal. When the acidity of the juice was abnormally low to begin with, the production of the lesion may raise the acid concentration. A true hyperacidity in the sense of a gastric secretion with a higher concentration of hydrochloric acid than is found in normal pure gastric juice was never observed.

THE SURGICAL TREATMENT OF TUBERCULOSIS OF THE GENITO-URINARY TRACT, INCLUDING THE KIDNEYS, BLADDER, TESTICLES AND SEMINAL VESICLES*

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The genito-urinary tract is seldom alone the site of tuberculosis, and primary genito-urinary tuberculosis probably never occurs. The frequency with which pulmonary tuberculosis, active, quiescent or healed, is found in careful routine postmortem examinations for tuberculous lesions indicates that a high percentage of adults have or have had pulmonary tuberculosis. It is generally accepted that tuberculosis of any part of the genito-urinary tract is hemotogenous in origin. The high incidence of pulmonary tuberculosis in necropsy records would seem to indicate that the lungs act as the primary focus for the secondary dissemination through the blood stream.

It is well known that in cases of active progressive pulmonary tuberculosis the disease is usually not confined to the lungs. Besides other parts of the body, the genito-urinary tract may be affected. In 500 necropsies on tuberculous subjects, Krzywicki [1] found 5 per cent. with involvement of the genito-urinary tract. Fowler and Godler [2] found 5.27 per cent., and Reclus [3] 12.8 per cent.

In a high percentage of cases of genito-urinary tuberculosis, there is tuberculosis elsewhere in the body. Various reports appear in the literature concerning the incidence of associated tuberculosis, which ranges as high as 80 per cent. Barney [4] reported an incidence of 55.8 per cent. of associated tuberculosis, the lungs having been diseased in 22.7 per cent. of his series of 154 cases of tuberculosis of the epididymis. Braasch,[5] in 1920, reported coincident clinical tuberculosis in the lungs,

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* From the Section on Surgery, Mayo Clinic.

* Read before the Western Surgical Association, Colorado Springs, Colo., Dec. 8, 1923.

1. Krzywicki, C.: Neunundzwanzig Fälle von Urogenitaltuberculose, darunter ein Fall von Tuberculose beider Ovarien, Beitr. z. path. Anat. u. z. allg. Path. **3**:295-334, 1888.

2. Fowler and Godler: Quoted by Barney (Footnote 4).

3. Reclus, P.: Du tubercule du testicule et de l'orchite tuberculeuse, Thesis, Versailles, 1876.

4. Barney, J. D., in Cabot, A.: Modern Urology, Philadelphia, Lea & Febiger, **1**:498-533, 1918.

5. Braasch, W. F.: Surgical Renal Tuberculosis: The Prognosis, Am. J. M. Sc. **159**:8-19 (Jan.) 1920.

bones and joints in 38.3 per cent. of 346 patients with renal tuberculosis. Of this series, 27 per cent. had definite clinical evidence of pulmonary involvement, and in an additional 5.3 per cent. the pulmonary disease was active. Therefore, it is evident that the successful management of tuberculosis of the genito-urinary tract includes the principles of treatment of general tuberculosis.

Considerable difference of opinion exists regarding the primary seat of tuberculosis in the genital tract. Barney and many others believe that the epididymis is the primary source, as the result of hematogenous infection; while Young [6] and others believe that the seminal vesicles are the primary source, the epididymis and testicles being infected subsequently through the lymphatics of the cord. Young asserts that not only may the seminal vesicles be the primary focus from which the epididymis is infected, but also, often, the prostate, bladder and kidneys. The preponderance of evidence would seem to favor the conclusion that the infection of the epididymis is primary and hematogenous, and that the seminal vesicles and prostate are infected secondarily, as the ureter and bladder are infected secondarily in renal tuberculosis. In support of the theory of a primary infection from the seminal vesicles, it seems not unreasonable to expect a demonstrable infection of the vesicles, if not also of the prostate, in all or most cases of tuberculous epididymitis. This has not been observed by advocates of the primary epididymal infection theory. Statistics quoted by Barney and others fail to show infection of the seminal vesicles and prostate in more than 75 per cent. of the cases of tuberculosis of the epididymis. In a series of sixty-six cases of tuberculous epididymitis at the Mayo Clinic, the seminal vesicles and prostate were affected in but fifteen (22.7 per cent.). Furthermore, the conservative surgical management of tuberculous epididymitis with associated disease of the vesicles and prostate has been productive of results which further support the theory that the primary focus is in the epididymis.

Genito-urinary tuberculosis is a disease of middle life. The average age of patients in a series of cases of renal tuberculosis in which operation was performed at the Mayo Clinic was between 20 and 40 years in 69 per cent; while in cases of tuberculosis of the epididymis, 75.7 per cent. of sixty-six cases occurred between the ages of 20 and 40 years.

SURGERY IN CASES OF RENAL TUBERCULOSIS

The kidney is most often involved in tuberculosis of the genito-urinary tract, and fortunately is usually unilateral. In a review of 227 recent cases of renal tuberculosis, tuberculosis of the genital tract was

6. Young, H. H.: The Radical Cure of Tuberculosis of the Seminal Tract, Arch. Surg. **4**:334-419 (March) 1922.

present in 37 per cent., clinical pulmonary tuberculosis in 32.45 per cent., and tuberculosis elsewhere in the body in 6.55 per cent. Even though associated tuberculosis existed in 77.9 per cent. of these cases, it was not considered a contraindication to nephrectomy. For years, the accepted method of treating unilateral renal tuberculosis has been nephrectomy through the posterolateral incision, as described by W. J. Mayo.[7] Cystoscopic examination and its allied methods of examination of the kidneys have placed the diagnosis of surgical renal lesions on the basis of an exact science. Reliable data are furnished concerning each kidney if need be, bilateral renal exploration being thus obviated. Bilateral renal tuberculosis presents a distinct contraindication to nephrectomy, unless there are acute unilateral complications. Active pulmonary tuberculosis associated with renal tuberculosis deserves careful consideration. As Wetherill[8] has aptly said, "The patient with active pulmonary tuberculosis is a substandard risk." In the event of an operation, he should be surrounded with every possible element of safety. However, in spite of active progressive pulmonary tuberculosis, the complications of closed renal tuberculosis are at times such that surgery is unavoidable, and with the present methods of administering local anesthetics or ethylene, the risk is minimal.

As approximately 80 per cent. of patients with surgical renal tuberculosis have associated tuberculous lesions, the latter, in the absence of general contraindications, should not deprive the patient of the benefit to be obtained by removal of the major tuberculous lesion, if this major lesion is unilateral renal tuberculosis. While seventy-four (32.45 per cent.) of 227 patients at the Mayo Clinic had associated pulmonary tuberculosis, but thirty-eight (16.7 per cent.) had clinical evidence of activity, and this, fortunately, was confined to small areas. Diffuse miliary tuberculosis is considered a contraindication to nephrectomy. Braasch concludes that associated tuberculous lesions exert but little influence on the ultimate prognosis, for the mortality rate is lower in the presence of coincident tuberculosis than that of the general average (Table 1).

The low primary mortality rate of less than 2 per cent. following nephrectomy for unilateral tuberculosis justifies the operation even if there is moderate pulmonary involvement. Braasch has reported a late mortality of 20 per cent. within five years after nephrectomy, with a prognosis of partial recovery for 80 per cent. of patients. Sixty per cent. were completely cured. Twenty per cent. had persisting bladder

7. Mayo, W. J.: Nephrectomy Without Drainage for Tuberculous Kidney, Surg., Gynec. & Obst. **15**:523-524, 1912.

8. Wetherill, H. G.: Surgery for the Tuberculous, J. A. M. A. **80**:6-8 (Jan. 6) 1923.

symptoms. The shorter the duration of the disease, the better is the result.

Persistence of a sinus after nephrectomy is due to incomplete removal of the diseased tissue, persisting infection in the ureter and the institution of drainage. While subcapsular nephrectomy is the operation of choice, it is inadequate in cases of extensive renal tuberculosis. The perirenal fat is often involved in extensive tuberculous pyonephrosis, and its incomplete removal favors a persisting sinus. The ureter is usually thickened and dilated and, if not actually tuberculous, presents a ureteritis which has in many instances been the cause of a persistent sinus. In an effort to obviate such a sinus, various methods of treating the ureter have been advocated, including injection of its lumen at the cut end with pure phenol, actual cautery sterilization

TABLE 1.—*Tuberculosis of the Kidney* *

	Cases	Per Cent.	Diagnosed Tuberculosis
Operations	228	.....	..
Nephrectomies	227	.....	..
Exploration	1	.....	..
Involvement of genital tract			
Prostate	40	17.54	17
Seminal vesicles	16	7.01	5
Testicles	13	5.70	1
Epididymis	30	13.15	14
Total	99	43.42	37
Previous history of pulmonary tuberculosis	11	4.18	..
Associated tuberculosis of			
Lungs (36 healed)	74	32.45	..
Spine	7	3.07	..
Spleen and liver (miliary)	3	1.32	..
Glands of neck	1	0.43	..
Wrist	1	0.43	..
Ankle	1	0.43	..
Fistulas	2	0.87	..

* From Jan. 1, 1920, to Sept. 1, 1923.

of the stump, bringing it to the surface of the skin and threading a tube over its end to carry subsequent drainage to the surface. Walters,[9] in a recent review of 282 cases in which nephrectomy had been performed for renal tuberculosis, found that ligation and sterilization of the cut end of the ureter with the actual cautery is the most satisfactory method of treatment. In 48 per cent., there was primary healing of the wound without drainage; whereas, in 27 per cent., the healing was secondary, with a sinus persisting temporarily in 25 per cent. A sinus of ureteral origin in the absence of ureteral stricture tends to close, and in most instances is of short duration. Low stricture of the ureter is best treated by ureterectomy at the time of nephrectomy. Judd's[10]

9. Walters, W.: Surgical Treatment of the Ureter in Tuberculosis of the Kidney, Minnesota Med. **6**:307-309, 1923.

10. Judd, E. S.: Surgery of the Kidney, Minnesota Med. **3**:221-227 (May) 1920.

method of threading the ureter into a tube closed at one end temporarily allows the sinus to be confined to the ureter in the event that the ureter opens, and avoids general contamination of the wound. Rarely is secondary ureterectomy necessary in the treatment of a persisting sinus.

The insertion of drainage tubes after nephrectomy for renal tuberculosis is as inadvisable as for tuberculous infection elsewhere. It invites secondary infection, and a postoperative persistent sinus results. Closure of wounds without drainage results in a high percentage of primary healing.

Tuberculosis of the bladder is usually secondary to renal tuberculosis, and its eradication is dependent on nephrectomy. Approximately 75 per cent. of patients with renal tuberculosis have involvement of the bladder. Braasch has shown that 48 per. cent. of patients who have preoperative symptoms of less than three or four months' duration improve immediately after nephrectomy, and that ultimately cessation of all urinary symptoms may be expected in 60 per cent. Palliative suprapubic cystostomy is occasionally necessary in the protracted cases of tuberculous cystitis of long duration with contraction to small capacity and associated irritability and frequency.

Tuberculosis of the seminal tract is often associated with renal tuberculosis, and while this would suggest a direct extension from the urinary tract, the evidence of its hematogenous origin seems conclusive. There is a tendency for tuberculous epididymitis to become bilateral, possibly by direct extension by way of the vas, vesicles and urethra. However, it is generally believed that, while extension by way of the lymphatics has its advocates, the infection is hematogenous. Various observers have reported bilateral involvement in from 25 to 75 per cent.

In twenty-four (36.3 per cent.) of the cases observed at the Mayo Clinic, the disease was bilateral at the time of examination. Sixteen patients had had orchidectomy elsewhere for positive or suspected tuberculous epididymitis, and two have since developed tuberculous epididymitis on the opposite side, a total of forty-two patients (63.6 per cent.) having bilateral disease.

While tuberculosis of the seminal tract may occur at any age, it is most common in the young adult, usually occurring in the third and fourth decades. Seventy-five and seven-tenths per cent. of the patients at the Mayo Clinic were between 20 and 40 years of age (Table 2).

Associated tuberculosis is common in cases of tuberculosis of the seminal tract. Barney asserted that more than 27 per cent. of 113 patients traced from one to twenty-five years after operation died from tuberculosis. Of the patients with tuberculosis of the seminal tract observed at the Mayo Clinic from Jan. 1, 1918, to Jan. 1, 1923, twenty-nine (43.5 per cent.) had other tuberculous lesions; ten (15.0 per cent.)

had pulmonary tuberculosis; two had Pott's disease; one had a tuberculous ankle, and sixteen had coincident renal tuberculosis or developed it subsequent to the epididymitis.

The question of involvement of the testicle in cases of tuberculous epididymitis is important from the standpoint of treatment. It has been generally accepted that tuberculosis in the testicle is rarely, if ever, primary, and that it is usually secondary to infection in the epididymis by direct extension. Balliano [11] recognizes a form in which the infection is primary simultaneously in the testicle and the epididymis, with its primary focus in the seminal canals. The testicle is usually involved only in extensive infection of the epididymis. On the basis of involvement of the testicle, castration has often been performed. The results, however, of the more conservative epididymectomy do not

TABLE 2.—*Age of Patients with Tuberculous Epididymitis*

Years	Cases	Per Cent.
15 to 20	2	3.0
21 to 30	24	36.3
31 to 40	28	42.4
41 to 50	9	13.6
51 to 60	2	3.0
61 to 70	1	1.5
Total	66	99.8

Oldest, 64 years; youngest, 16 years; average, 33.9 years; 78.7 per cent. between ages of 20 and 40.

warrant orchidectomy as a routine procedure for tuberculous epididymitis. Baumgarten [12] has shown that spermatogenesis occurs even in a testicle extensively involved. It has been asserted that masculinity is not impaired after double orchidectomy. Simon reports normal sexual function in twenty-nine cases of double orchidectomy. However, the frequency with which tuberculosis of the epididymis is, or becomes, bilateral places much responsibility on the orchidectomist, which can be materially reduced by epididymectomy in most instances, with complete eradication of the disease locally, usually without appreciable testicular atrophy, and unquestionably preserving testicular function.

OPERATIVE PROCEDURES

On the basis of the difference of opinion concerning the primary seat of involvement of seminal tuberculosis, the surgical treatment of the disease may be classified as conservative and radical. Those inclined

11. Balliano, A.: Ueber einen Fall von primärer Tuberkulose der Samenkanälchen des Hodens und des Nebenhodens, Beitr. z. Klin. d. Tuberk. **25**:385-411, 1912.

12. Von Baumgarten: Experimente über ascendierende Urogenitaltuberkulose, Verhandl. d. deutsch. path. Gesellsch. **9**:2-5, 1905.

to consider the epididymis the primary source of the infection accept the conservative method of epididymectomy; while those regarding the seminal vesicles and prostate as the primary source advocate the radical operation of excision of the epididymis, vas, seminal vesicles and prostate when involved. Young recently reported fifteen cases in which the radical operation had been performed with excellent results. The radical operation unquestionably eradicates the disease in the seminal tract. However, the excellent results of conservative operation do not justify the radical operation. For whether tuberculosis is primary in the vesicles and prostate or in the epididymis, the quite universal result has been that, after epididymectomy, the disease in the vesicles and prostate tends to subside. This has been confirmed by reexamination in many of our cases.

TABLE 3.—*Involvement of the Epididymis*

	Cases	Per Cent.	Cases	Per Cent.
Right epididymis	21	31.8	..	....
Left epididymis	21	31.8	..	....
Bilateral	24	36.3	24	36.3
Previous castration	..	....	16	24.2
Subsequent right epididymectomy	..	....	1	1.55
Subsequent left epididymectomy	..	....	1	1.55
Total	66	....	42	63.6
Type of operation				
Bilateral epididymectomy	18	27.2	..	....
Left epididymectomy	17	25.7	..	....
Right epididymectomy	16	24.2	..	....
Bilateral castration	1	1.5	..	....
Left castration	4	6.0	..	....
Right castration	5	7.5	..	....
Right castration and left epididymectomy	5	7.5	..	....
Total	66			

RESULTS

From Jan. 1, 1918, to Jan. 1, 1923, sixty-six patients were operated on at the Mayo Clinic for tuberculous epididymitis without a hospital death. Sixteen had had unilateral castration for definite or suspected tuberculous epididymitis from three months to fifteen years before; ten had associated renal tuberculosis; five had had a nephrectomy for renal tuberculosis from nine months to four years before, and twenty-two had definite digital evidence of involvement of the vesicles or prostate.

Bilateral epididymectomy was performed in eighteen cases (27.2 per cent.), left epididymectomy in seventeen (25.7 per cent.), right epididymectomy in sixteen (24.2 per cent), bilateral castration in one (1.5 per cent.), left castration in four (6.0 per cent.), right castration in five (7.5 per cent.), and right castration and left epididymectomy in five (7.5 per cent.) (Table 3).

Through reexamination and questionnaires, the condition of forty-nine (71 per cent.) of these patients has been ascertained. There was a persisting sinus in but one case. The testicle was slightly smaller in 40 per cent.; there was no change in the size in 52 per cent., and it was slightly enlarged in 8 per cent. In cases in which there was unilateral epididymitis at the time of operation, the opposite epididymis remained free from infection for from one to five years, except in two, and in one of these castration was performed subsequently. There have been no urinary symptoms in 80 per cent. In 66 per cent., there has been a gain in weight of from 10 to 25 pounds (4.5 to 11.3 kg.). Only one patient has lost weight. Eighty-eight and five-tenths per cent. of the patients are well or markedly improved. One patient only is worse, as a result of general tuberculosis, which was present at the time of operation.

Even though most patients with tuberculosis of the epididymis have one or more scrotal sinuses, the high inguinal incision is preferable to the scrotal incision. The contents of the scrotum are readily drawn up into the incision, excision of the epididymis, the involved tunica vaginalis and sinus, together with the vas as high as the internal inguinal ring, thus being facilitated. Primary healing of the wound is the rule. Excision of the involved and inflammatory tunica vaginalis is important for early closure of scrotal sinuses. While castration is sometimes necessary in cases of extensive involvement, resection of the testicle is readily accomplished in cases of partial involvement. The frequency of bilateral tuberculosis of the epididymis should condone the promiscuous orchidectomy for either unilateral or bilateral involvement, if for no other reason than its mental and physical effects. The excellent results of simple epididymovasectomy do not justify the more radical operation.

The frequent occurrence of tuberculosis in other organs coincident with genito-urinary tuberculosis demands the application of the general principles of management of tuberculosis, in addition to the surgical principles briefly stated.

LIPOMA OF THE THIGH

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Although lipomas are frequently seen, lipomas of the thigh seem to be rare. Their possible malignant character and their tendency to recur after removal are the reasons for calling attention to them. About the first clinical reference to the malignant type of lipoma found is that of Senn,[1] who in discussing lipomyxoma of the neck mentions seeing a patient bearing such a tumor the size of an adult head between the adductor muscles of the thigh. In 1914, P. G. Skillern, Jr.,[2] reported fibrolipomas of the thigh in a white woman, aged 54. These tumors were located on the upper inner portion of each thigh, that on the left side being the larger, about the size of a pear. Beriel and Delachanal[3] described such a tumor of one year's duration, on the back of a woman's thigh. At operation, the tumor was found to take origin in the sheath of the sciatic nerve, and although a 6½ pound (about 3 kg.) tumor was removed, within six months metastases developed in the lumbar lymph nodes and the fatty capsule of the left kidney. At a second operation, this kidney and the lymph nodes were removed, but the patient died eighteen months after the first operation. Necropsy revealed secondary involvement of the right lumbar fossa, right lung, omentum and intermuscular cellular tissues of the neck. The histologic examinations revealed the lipomatous origin of both the primary tumor and the metastases. At certain points, the tumor took on myxomatous and sarcomatous characteristics.

Broca's case is quoted by Warthin[4] and Wells.[5] A man, aged 31, at the age of 25 noticed a tumor of the thigh. A lipoma weighing 5 pounds (about 2.3 kg.) was removed, and within five months hundreds of small fatty tumors (2,080 in all) appeared, all over the body. These persisted and enlarged for forty years, until the man was nearly 70 years old. Dysphagia and emaciation then came on rapidly, and as emaciation became extreme, the fatty tumors diminished in size.

A similar case of diminution in size of fatty tumors was reported by Baker.[6]

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1. Senn, Nicholas: St. Paul M. J., Jan. 1, 1899.
2. Skillern, P. G., Jr.: Internat Clinics, Series 24, 1914, p. 1-187.
3. Beriel and Delachanal: Arch. de méd. exper. et d'anat. path. **24**:717, 1912.
4. Warthin: Reference Handbook of Medical Science, New York, William Wood & Co. **6**:19, 1916.
5. Wells, H. G.: Fat Metabolism of Lipomas, Arch. Int. Med. **10**:297 (Oct.) 1912.
6. Baker: Tr. Path. Soc. London **30**:417, 1879.

Meyer [7] reported an instance of lipoma of the thigh in a man. This tumor had been noticed for three months, but had not disturbed the action of his knee joint. It had a clinical appearance of periosteal sarcoma, but when cut down on was found to be a large lipoma attached along the periosteum of the femur and to the knee joint synovial surface. Complete removal was performed, necessitating opening and closing of the knee joint. The tumor seemed to spring from the subserous fat around the knee joint. In a discussion of this case, Weir reported one of his own cases, in which the tumor was located on the outer aspect of the leg. Since aspiration was negative, the tumor was cut into, and a lipoma was found, which was completely dissected away. It involved and was largely contained in the extensor digitorum muscle, although numerous outgrowths were found in the intermuscular septums. The tumor weighed 2 pounds (about 1 kg.), and while there was some interference after operation with the function of the muscle involved, this was improving after two years.

The character of these tumors is discussed by Wells, and two of the cases herewith reported confirm clinically some of his observations.

Lipoma in the human being may be subcutaneous, subserous, submucous, intermuscular or periosteal, or may be in the joints or in internal organs. It may also appear as a congenital tumor, when it is quite liable to develop malignant tendencies. Wells demonstrated that huge intraperitoneal lipomas continue to grow and enlarge at the expense of the rest of the body, exhausting normal fat deposits. They possess a marked tendency to myxomatous change and resemble malignant tumors in their fatal outcome. They also tend to recur after removal and probably undergo sarcomatous transformation. The tumors so inclined are more cellular than ordinary lipomas; and whether the malignant aspect is present from the onset of the tumor growth, and is lighted up by trauma, operative or otherwise, or whether the stroma cells undergo a metaplasia is not known. They possess lipase and lipolytic power, and have been compared to the humps of dromedaries which start on a journey across deserts with full, erect humps, but reach their destination with their humps pendant flabby bags of skin. They may also be compared to the tails of the fat-tailed sheep and the steatopygous masses of the Hottentots. Possibly, some might be labeled lipoplastic sarcoma, in which the fat cells infiltrate into the sarcomatous structure. Oil cysts and necrotic areas may be found. Sarcomatous or myxomatous changes may be induced by edema, stasis or the action of lipase.[8]

Senn believed that the intermuscular lipomas were more liable than the superficial tumors to undergo transition into sarcoma, but he knew

7. Meyer: Ann. Surg. **26**:23, 1897.

8. Borst: Pathologic Histology, pp. 305-306, 1922. Kaufmann: Spez. Path. Anat. **2**:1312, 1911.

that myxomatous degeneration was common; and he argued that the stage of development at which the mucous cells of the embryo were arrested determined whether the tumor from such a matrix became myxoma, fibroma or myxolipoma. Certainly embryonic connective tissue is identical with Wharton's jelly, the prototype of myxomatous tissue which these tumors appear to be after recurrence. The capsules of such tumors are thin and poorly developed, so that removal by enucleation is practically impossible. Incomplete removal seems to be

Fig. 1 (Case 1).—Appearance of patient after recurrence; scar of first operation and spreading of tumor growth under Poupart's ligament into the abdomen. The size is about that of the original tumor.

the rule, even if the tumor has not already undergone malignant change.

Clinically, lipoma or lipomyxoma of the thigh is of slow growth. Its surface is smooth, and is rarely lobulated. It is movable unless tied down by overlying adjacent tissues, which it may displace and infiltrate. On palpation, a feeling of semifluctuation is found and there is neither pain nor tenderness. At a glance, the tumor may appear

to have malignant characteristics. On the skin surface may be found dilated veins. Tumors of long continued growth appear fixed, and are clinically classed as sarcoma. One of the cases here reported had an infected pressure sore on the surface, from which a foul discharge emanated, at once lending a sarcomatous appearance to the mass. The semifluctuant sensation found on palpation may induce the surgeon to insert an aspirating needle in the hope of discovering a cyst.

REPORT OF CASES

CASE 1.—*History.*—A man, aged 60, a furrier by occupation, five years before being seen in April, 1922, had struck his right thigh while moving a piano. Fourteen days later, he noticed a small tumor on this thigh. The skin had not been broken, and no treatment was given. During the four years following the tumor mass steadily increased in size. Swelling developed in the leg, and the patient entered a hospital. After several injections (mixed toxins?) and a dozen roentgen-ray treatments, the leg appeared normal, but the tumor mass in the thigh remained.

Examination.—When the patient was seen in April, 1922, there was a large smooth swelling of the upper anterior and outer surface of the thigh, not very soft, with dilated veins over it, but not much swelling in the leg. He was apparently in good health; had no cough, and weighed 170 pounds (77.2 kg.), which he considered slightly less than his previous weight. He had lost no strength, but for the last eight months he had suffered pain in the thigh as far down as the knee, and he found that the tumor interfered with walking and with crossing his legs while working.

He was sent to the hospital. A roentgenogram of the chest was negative. A piece of tissue was removed from the tumor for microscopic examination. Nothing more than an apparently pure lipoma was found, and on the next day a complete removal of the mass was undertaken.

Operation.—A long incision was made down the front of the thigh, lateral to the great vessels. The tumor proved to be fairly well encapsulated in its anterior aspect, but seemed to extend up under Poupart's ligament along the course of the femoral canal. The ligament was cut, so that all of the tumor tissue could be removed from the direction of the abdominal cavity. The gracilis muscle had been completely destroyed by the tumor at about the upper third of its extent. The adductor longus was also infiltrated, and some of its fibers were so damaged that these, together with the gracilis, were completely removed. The tumor spread further down and was wrapped about the sheath of the great vessels, but did not seem attached to the femur; nor was the periosteum of the femur found wanting in any respect. After a long dissection, as much of the tumor mass as could possibly be removed without injuring the great vessels was cut away, and the enormous thigh wound was closed.

Course.—The wound drained serum and oily material for several days; the swelling in the leg rapidly subsided, and the patient left the hospital in eighteen days with the thigh and leg in good shape. He returned for inspection after one month with the wound completely healed, and presented no signs of leg swelling or recurrence of the tumor. Sections made from several areas of this large fatty mass, which weighed over 9 pounds (4 kg.), failed to reveal any difference pathologically from an ordinary lipoma.

Thirteen months after operation, he returned with recurrence in this upper portion of the thigh, so that the mass appeared about as large as it had originally. There was great edema of the leg, some blotchy spots on the skin of the thigh and evident pressure on the great vessels in Scarpa's triangle. The scar and skin over the tumor were intact. The original specimen removed was then reexamined by gross serial section, and an area the size of a lemon was found deep in the tumor mass, which appeared to be myxoma.

Second Operation.—At this exposure, the tumor mass had taken on an entirely different appearance. It was soft, gelatinous, edematous and yet fatty

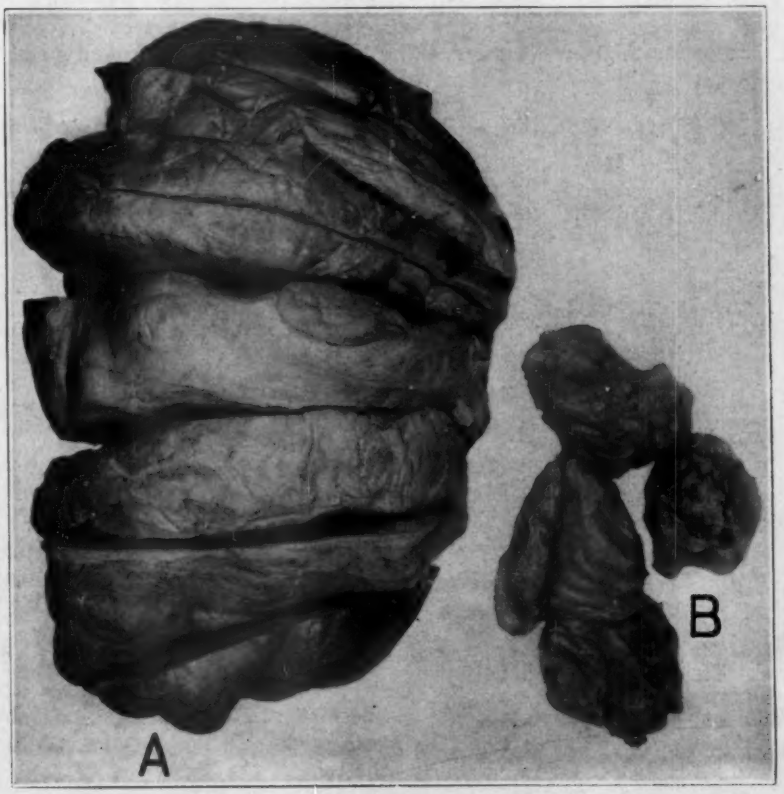

Fig. 2.—*A*, mass of gross specimen removed at first operation; *B*, a small piece of myxomatous material removed at the second operation. Unfortunately, the photograph does not show the difference between the two specimens.

and pale yellow, but probably malignant. Several pounds of this material was removed, some from beneath the peritoneum in the abdomen when the incision above Poupart's ligament was followed up. The great vessels were so securely surrounded by it and the disease had progressed so far toward the abdomen that no amputation seemed to offer any chance for cure. As much tumor mass as possible was removed and the wound was closed.

Outcome.—Healing followed rapidly, the leg improved and roentgen-ray treatment was started in a few days. The patient left the hospital in two weeks

and has returned regularly for roentgen-ray treatment. At this time, he is bedridden with pain and the enlarged edematous leg and thigh, and begs for amputation. Up to three months after the second operation, no metastases could be demonstrated in the lungs.

CASE 2.—*History.*—A man, aged 42, Polish, a laborer, first noticed swelling in the right thigh five years before he was first seen (August, 1923). A small lump appeared on the mesial aspect of the upper third of the thigh, which was painless and caused no inconvenience. It increased constantly in size, and after one year, a piece was removed by a physician of his own nationality, who told him the tumor was "flesh." On inquiry into the history, it was found that in his occupation as a miner for twelve years the right arm used to rub over the part of the thigh where the swelling began. He had never been sick.

Fig. 3 (Case 2).—Appearance of tumor of thigh. *A*, lateral view. *B*, front view. The leg shows no swelling. *C*, back view. *D*, medial view. A few enlarged veins appear on the surface of the thigh. The leg is normal.

Physical Examination.—No abnormalities were revealed except the huge tumor. The right thigh was occupied by an enormous mass which involved the anterior, posterior and mesial portions, extending down to the popliteal space. Its consistency was uniformly quite hard and no lobules were felt. It was painless, and the skin over it was a little dry and scaly. On the mesial aspect of the thigh near the knee was an 8-inch (20 cm.) healed surgical scar. The thigh was 32 inches (80 cm.) in circumference. The strength and movements of the leg and thigh were normal, and when the thigh muscles were contracted in exertion, the whole tumor mass became harder than in relaxation. No edema or varicose veins were present in the leg. A bone cyst, osteochondroma and fibrolipoma were considered as possible diagnoses. The urine and blood were normal.

Operation.—After preparation of the skin with picric acid an anterolateral incision was made in the thigh from the femoral ring to the knee. The tumor mass, which appeared as yellow fat, was dissected free by the fingers. Several superficial muscle bands were taken away along with the fatty tissue. The femoral vessels and the profunda were exposed and stripped. The femur was exposed and its periosteum carefully examined for a possible connection with the tumor mass. There was adherence to other tissue, but no closer relationship. One large branch of the femoral vein had to be ligated. In the effort to remove the deep portion, the sciatic sheath was brought into view, but it did not seem to be invaded. At the lower end, the knee joint was opened in the effort to get out all the tissue. The joint cavity was closed with a con-

Fig. 4 (Case 3).—Front view: Near the pubes an area of necrosis developed from which there was a serous surface discharge. This tumor is more pendulous than the two preceding. Lateral view: Area of origin and pendulous appearance.

tinuous catgut suture. The muscles were approximated, and the skin was closed with drainage. The fat mass removed weighed 23 pounds (10.4 kg.).

Some shock, and sloughing of skin, occurred after operation, but the wound healed without serious infection and is now granulating. The patient can walk about and has no loss of muscle power or sensation in the leg, which still presents no edema. It is now three months since operation, and we cannot yet determine that there is evidence of recurrence.

Case 3.—*History.*—A man, colored, aged 28, two and one-half years before had noticed a walnut-sized swelling below the left groin, which gradually increased in size and took on a pendulous character, and extended down the

thigh. In the last six months, it had grown more rapidly and recently developed a pressure necrosis over the lower end. The ulcer had become infected, and discharged a thin foul-smelling grayish serum.

Examination.—The tumor was about 8 inches (20 cm.) long and 6 inches (15 cm.) wide, with a fairly well defined pedicle. It was quite hard, had a smooth surface and seemed to hang from the subcutaneous tissues of the upper thigh just below Poupart's ligament. A general physical examination was negative. The Wassermann test was negative.

Operation.—Under a general anesthetic, the tumor was dissected completely away, in September, 1923. It did not seem to dip under Poupart's ligament, nor to involve the adjacent muscles, but was quite firmly adherent to the sheath of the great vessels. After removal, it weighed nearly 3 pounds (1.3 kg.). It was bluish gray and gelatinous, with much fat, and exuded watery fluid when pressed. Clinically it looked malignant.

Microscopic Examination.—The microscopic section showed a fibrolipomatous mass with much myxomatous degeneration and with round-cell infiltration near the infected area. A diagnosis of myxolipoma was made.

Outcome.—The wound closed by granulation, and the patient left the hospital.

CASE 4.—*History.*—A man, aged 40, nearly two years before, while on a trip in Texas, noticed that the left thigh felt a little numb on the outer aspect after several days of hard work and a prolonged upright position. A few days later, he noticed a sligh swelling on the outer aspect of the thigh above the area of numbness. No edema, loss of power or pain appeared in the leg. In October, 1923, a small tumor mass 2 by 3 inches (5 by 7.5 cm.) appeared high on the outer aspect of this thigh. It bulged beneath the skin, was quite soft, did not seem closely attached to the fascia below and was symptomless. Because a continued growth of this tumor was feared, excision was advised.

Operation.—October 11, with a local infiltration of 1 per cent. procain, the mass, with the skin over it, was excised, the apparent swelling being avoided and the underlying fascia removed. The fascia was brought together and the skin was closed.

Outcome.—Healing with considerable drainage followed promptly.

Microscopic Examination.—The tumor mass was purely fatty, with rather a rich stroma, but no evidence of sarcomatous or other degeneration. We hope that this early and radical removal will result in a permanent cure.

PNEUMARTHROSIS AS A DIAGNOSTIC AID

REPORT OF A CASE OF LOOSE INTERNAL SEMILUNAR CARTILAGE

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In an article published several years ago,[1] I pointed out the value of injecting oxygen into joints before subjecting them to roentgen-ray examination. I indicated how this method may be employed to advantage in various joints, described a simple technic and reported specific instances wherein this procedure aided in establishing a diagnosis or was the only means that enabled us to recognize and define the pathologic changes. So far, pneumarthrosis has proved of greater and more frequent benefit in the study of the knee than of any other joint.

For want of more accurate information, we have been compelled in the past to group many obscure lesions of the knee joint in the category of internal derangements. As our knowledge in differential diagnosis improved, we removed from this class cases of loose internal semilunar cartilage, injury of the crucial ligaments, fracture of the tibial spine, chronic hypertrophic villous synovitis, and so forth. When the derangement can probably be cured by operation, it is all the more important to utilize every known measure to arrive, if possible, at an absolutely accurate diagnosis. From this standpoint, the condition of loose internal semilunar cartilage of the knee joint is specially interesting. In most cases, the history of an injury, locking of the joint, disability and localized pain and tenderness form a picture that it is easy to interpret. At times there are difficulties due to the absence of one or another of the salient features, and additional means of obtaining a correct diagnosis is welcome. The shadow of a semilunar cartilage that is in intimate contact with the tibia is not ordinarily distinguishable from that of the tibia. In the usual anteroposterior roentgenogram of the knee, we see a clear space between the tibia and the femur. If the cartilage, loosened by injury or otherwise, can in some way be lifted up and away from the tibia, its shadow, though not so dense as that of the subjacent bone, will be recognizable. I recently[2] reported a case in which the diagnosis of loose internal semilunar cartilage, doubtful from the history and examination, was confirmed by pneumarthrosis and roentgenography and proved at the operation. The cartilage appeared as a transverse linear shadow above the internal tuberosity of the tibia.

1. Kleinberg, Samuel: Am. J. Surg. **35**:256 (Sept.) 1921.
2. Kleinberg, Samuel: New York M. J., to be published.

The object of this communication is again to call attention to the value of this very simple procedure and to report another case of loose internal semilunar cartilage of the knee in which the use of pneumarthrosis was valuable in establishing the diagnosis and determining the proper therapy.

When I first began to inject oxygen into joints, I was, naturally, greatly concerned about the possibility of infection. Extensive precautions were taken and the injection was made in the operating room. This has been found wholly unnecessary. The operation can be performed in the roentgen-ray laboratory, and any of the assistants in that department may be used as an aide.

The sterile tray contains supplies for preparing one's hands, such as soap, sterile brushes, alcohol, sterile gloves and powder. In addition, there are sterile towels, gauze, iodin, a long rubber tube and several fairly stout needles. An ordinary tank of oxygen is used. The rubber tube with the needle attached is secured to the nozzle of the tank and some of the gas is allowed to pass through the tube and needle. This is an essential detail as it not only clears the whole tract of undesirable particles, but also enables the aide to discover the proper strength of the current to be used. A current that is too strong will distend the joint so rapidly that it will cause much discomfort. If the pressure is very slight, the oxygen will enter the joint very slowly, and hence the operation will be unnecessarily long and the oxygen will have time to become diffused through the periarticular tissues instead of remaining within the joint.

The whole operation should not take more than from three to five minutes. I have not had any untoward effects in an experience of about forty injections, most of which were made into the knee joint. The gas is absorbed in a day or two, and as it is not painful (except during the injection), I have not deflated the joints. There is no rule about the degree of distension. I allow the gas to flow in until all of the hollows and markings about the joint are obliterated and there is a moderate swelling. At this stage, the patient has discomfort, but no great degree of pain. There is no advantage in extreme distensions as they only cause much pain and force much of the gas into the surrounding subcutaneous tissue and intermuscular planes.

REPORT OF CASE

History.—S. C. P., a man, aged 37, referred to me, Sept. 9, 1923, by Dr. I. Rosenthal of Brooklyn, for pain and stiffness in the right knee, about three and one-half months previously discovered quite accidentally that he was unable to bend his right knee as far as he could the left. From that time on until six days before consulting me, he had had several attacks of transitory pain in the right knee, but these were not severe and there was no disability. Six days prior to his first visit, while trying to get up from the sitting position, he felt

a sharp pain in the right knee, both under the knee cap and on the inner side. The knee became swollen and he was compelled to go to bed. He has since suffered from pain, swelling and stiffness of the right knee, but he has not had any locking of the joint. He pointed to the inner side of the knee as the location of his greatest pain.

Examination.—The patient was in good general condition. He was able to walk unassisted, but there was a limp on the right side. The right knee was swollen and flexed to 165 degrees, but it was neither red nor hot. There was marked tenderness of the inner side of the knee at the joint line, especially

Left: Anteroposterior view of knee before oxygen injection. The clear space between the tibia and femur may be noted. Right: Anteroposterior view of same knee after oxygen injection. The large intra-articular shadow between the internal tuberosity of the tibia and the femur may be noted. There is a clear space above and below this shadow due to the gas around it. The internal meniscus giving the intra-articular shadow has been lifted from the tibia.

if pressure was applied downward over the tibia. There was no loose or displaced mass visible or palpable. There was an effusion into the joint.

While it was likely that there was a loose internal cartilage, certain essentials to such a diagnosis were wanting. There was no history of an injury, and there had never been even a suggestion of locking. The swelling, pain and tenderness evidently could have been due to other lesions of the knee. Hence,

it was decided to inject the knee with oxygen and make a roentgen-ray examination.

The patient was accordingly admitted to the Hospital for Ruptured and Crippled, and after the usual preparation, the joint was examined by roentgen ray, injected with oxygen and examined again. An anteroposterior view before the injection is shown in the accompanying illustration (left). This shows no abnormality. The space between the tibia and femur is apparently clear. The appearance after the joint was inflated with oxygen is shown on the right. There is a wedge-shaped shadow above the internal tuberosity of the tibia. The base of the wedge is internal and the apex is in contact with the tibial spine. There is a distinct interval of from one-eighth to one-quarter inch (0.3 to 0.6 cm.) between this shadow and that of the tibia. The wedge shape of this intra-articular shadow is very distinct in the original film but is not very clear in the reproduction.

The wedge-shaped shadow between the internal tuberosity of the tibia and the femur was diagnosed as that of the internal semilunar cartilage, which was loose and pathologic and hence required removal.

Operation and Result.—(October 5).—The usual small vertical incision on the inner side of the patellar ligament was made. The internal meniscus was found entirely detached, loose and folded upon itself except at the extremities or cornua, which were attached near the tibial spine. The cartilage was removed and the wound sewed up in layers. Healing took place by primary union and the patient made a complete recovery.

COMMENT

This case is reported to emphasize the usefulness and the harmlessness of pneumarthrosis. It is, of course, not intended that this procedure be used indiscriminately or without due regard to asepsis, and it is unwarranted when the diagnosis is clear. But it is very helpful in many obscure conditions and is not being employed so often as it should be, because it is not generally appreciated that the inflation of a joint with oxygen is both simple and free from danger. The special interest in the case herein cited is due to the opportunity of again demonstrating roentgenographically a pathologic cartilage.

THE RENAL CIRCULATION *

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The following investigation was undertaken in the hope that actual photographic records might be submitted of the renal vessels in the later stages of their distribution and that the evidence produced might definitely eliminate the doubt that exists regarding certain features of their finer circulation. A review of the literature reveals an inconsistency of findings, together with a certain looseness of terminology. Slight differences in terminology are to be expected, but one does not expect to find such diversity of opinion regarding the finer circulation of an organ of such importance as the kidney.

The two outstanding points of controversy seem to be (*a*) the origin of the arteriae rectae of the medulla and (*b*) the existence or non-existence of any blood supply to the cortex from the renal artery, which has not previously traversed a glomerulus.

In 1842, Bowman [1] wrote his classic account of the renal circulation. He states "All the blood of the renal artery (with the exception of a small quantity distributed to the capsule, surrounding fat and the coats of the larger vessels) enters the capillary tufts of the malpighian bodies; thence, it passes into a capillary plexus surrounding the uriniferous tubes, and it finally leaves the organ through the branches of the renal vein." He therefore concluded that the cortex did not receive any direct blood supply that had not previously passed through a glomerulus, and also that the arteriae rectae originated as efferent glomerular vessels. The latter view is supported by Gerlach,[2] Kolliker,[3] Ludwig,[4]

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1. Bowman: On the Structure and Use of the Malpighian Bodies of the Kidney, with Observations on the Circulation Through the Gland, Phil. Tr. Royal Soc. London, 1842, p. 57.

2. Gerlach: Handb. der allgem. und speciell. Gewebelehre des menschlichen Körpers, Wein, 1860, p. 355.

3. Kolliker: Histologie oder die Lehre von den Geweben des Menschen. Uebers, aus dem Russ. nach der 4, Aufl. von Kowslewsky, 1865, p. 551.

4. Ludwig, C.: Zur Anatomie der Niere. Sitzungsber. der Wien. Akad Mathem. naturwissensch. Cl. **48**:704, 1863; Handbuch der Lehre von den Geweben des Menschen und der Thiere, S. Stricker, 1872.

Gross [5] and Huber [6] and modified by Huschke [7] and others who attributed the origin of some arteriae rectae to the capillary plexus surrounding the tubules in the cortex.

The generally accepted teaching, originating with Virchow,[8] is that there are two distinct types of arteriae rectae. The first of these is described as arising directly from the arcuate arteries and, without being in any way associated with a glomerulus, passing down between the collecting tubules of the medulla. These are termed the arteriae rectae verae. The second type, while pursuing a similar course, differs from the first in originating from glomeruli. These are termed arteriae rectae spuriae.

With regard to the existence or nonexistence of a direct blood supply to the cortex, that has not previously passed through a glomerulus, no very conclusive evidence has been submitted.

MATERIAL

During this investigation, more than 250 sections of varying types of mammalian kidneys have been examined in detail. Though a large variety of mammalian kidneys have been employed for comparative studies, the majority of these specimens were directly prepared from human material.

FINDINGS

The renal artery, on approaching the hilum of the kidney, divides into two sets of branches, an anterior and a posterior, of which the former is generally the more extensive. These branches diverge as the pelvis of the kidney is approached, till they come to lie between the calices in close apposition to its anterior and posterior aspects. Here, a further series of branches is given off, which run in the direction of the capsule between the pyramids, whose apices open into the calices. This position is retained till the corticomedullary zone is reached, a point corresponding to the bases of the pyramids. These are termed the interlobar arteries. On reaching the corticomedullary zone between the bases of the pyramids, they become the arcuate arteries. In view of the conical shape of the pyramids, it will be seen that, as their bases are approached, the interlobar arteries are gradually pushed outward.

5. Gross, L.: Studies on the Circulation of the Kidney in Relation to Architecture and Function of the Organ in Health and Disease, J. Med. Res. **34**:327-335 (July) 1917; ibid. **38**:379-384 (July) 1918.

6. Huber, G. C.: Arteriolae Rectae of the Mammalian Kidney, Am. J. Anat. **6**:391-406, 1906-1907.

7. Huschke: Oken's Isis **21**:563, 1828; Citirt Nach Chrzonszczewsky, Virchow's Arch. f. Path. Anat. **31**:175.

8. Virchow, R.: Einige Bemerk. über die Circulations-Verhalt-nisse in den Nieren, Virchow's Arch. f. path. Anat. **12**:317, 1857.

Arriving at the corticomedullary zone, they continue toward the midline, and in passing over the bases of the pyramids, describe slight curves with convexities toward the periphery. To this particular arching is due the name arcuate artery.

These arcuate arteries give off a series of branches from their convexities called interlobular arteries, and, after rapidly diminishing in caliber, take a more peripheral turn and themselves terminate as interlobular arteries.

Branches are given off from both the convexity and concavity of the arch formed by an arcuate artery. From the convexity arise the interlobular arteries and a few afferent glomerular branches. From the concavity arise small glomerular-bearing arteries and varying types of afferent glomerular vessels, which will be described later.

It is the object of this article to deal in detail with the microscopic distribution of the renal artery, which is constituted by its branchings from this point onward to the finest capillary ramifications.

INTERLOBULAR ARTERIES

The arcuate arteries, as they progress, give off the interlobular arteries from the convexities of their arches, at somewhat regular intervals and angles, varying with their points of origin. These arteries run almost directly toward the periphery, so that the interlobular arteries given off by any one arcuate artery are more or less parallel. This arrangement is not universal, as the course of the interlobular arteries is governed almost entirely by the distance of its point of origin from the periphery, the course taken being generally the shortest possible route to the periphery. In unilobed kidneys, the interlobular arteries would be practically parallel except for a slight radiation; but in multilobed kidneys, this would not be the case, as here infoldings of the cortex occur (transverse and longitudinal columns of Bertini), and at these points there would be exhibited an interdigitation of these vessels.

Interlobular arteries, while generally arising from the convexities of the arcs described by the arcuate arteries, may sometimes arise from their concavities. The latter vessels are only occasionally met and are much smaller than the former. While the artery is usually seen to be a single trunk and to extend from corticomedullary zone to cortex corticis, this is not universal, as such a vessel may subdivide into smaller divisions during its course or may terminate in a deeper area of the cortex before reaching the cortex corticis.

Interlobular arteries may terminate, (*a*) as an afferent glomerular artery to one or more glomeruli; (*b*) by breaking up directly to supply the convoluted tubules, in the cortex corticis; (*c*) as a perforating capsular artery.

(*a*) The interlobular arteries generally terminate in this manner by supplying the glomeruli in the area immediately, deep to the cortex corticis (Fig. 1).

(*b*) Occasionally, these vessels terminate directly by breaking up into a plexus surrounding the tubules in the cortex corticis, contradicting Bowman's theory. This represents a blood supply that has not previously passed through a glomerulus (Fig. 2).

(*c*) The interlobular artery may, after giving off its last afferent glomerular branches, continue on through the cortex corticis as a perforating capsular vessel. Such vessels are much more frequently found in some animals than in others. In sheep, they are scarcely ever seen; in the human being, they are not infrequent; in dogs, they are commonly met.

Two series of branches are given off by the trunk of the interlobular arteries; i. e., afferent glomerular branches and direct nutrient vessels. The afferent glomerular vessels take origin from all aspects of the artery, like the branches of a tree, and after running a course varying with the situation, terminate in glomeruli (Figs. 3 and 14). Direct nutrient vessels are found arising from these trunks, which without passing through a glomerulus break up into a plexus surrounding the tubules. These vessels are not very common and are to be regarded as more or less exceptional (Fig. 4).

THE GLOMERULUS

The glomerulus is composed of a branching system of vessels, varying in caliber formed by the branching and rebranching of the afferent glomerular vessel on entering Bowman's capsule (Fig. 5). These branches reunite to form the efferent vessel or vessels, which emerge from the capsule to supply the tubules. Glomeruli have been observed in which the afferent vessel has split into two branches before entering the glomerular capsules, resulting in a twin-glomerular appearance (Fig. 6). This fact has previously been noted by Beer.[9]

Glomeruli are found in greatest numbers in the more peripheral part of the cortex, directly subjacent to the cortex corticis. The latter area, which lies immediately beneath the capsule, is devoid of glomeruli, consisting entirely of convoluted tubules. In the more medullary part of the cortex, the glomeruli diminish in numbers, owing to the increasing area occupied by the tubules.

The size of the glomerulus is practically uniform, except in the case of those nearest the medulla. In this locality, especially in the

9. Beer, E.: Ueber das Vorkommen von Zweigeteilten Malpighi 'schen Körperchen in der menschlichen Niere, Ztschr. f. Heilk. wien u. Leipzig **24:** 334-337, 1903.

Fig. 1.—Subcapsular type of efferent: a glomerulus immediately subjacent to the cortex corticis being supplied by one of the three terminal afferent glomerular branches of an interlobular artery. The efferent is proceeding in a capsular direction and is forming an extremely dense plexus around the convoluted tubules in the cortex corticis. The latter directly subcapsular area is observed to be entirely devoid of glomeruli.

Fig. 2.—An interlobular artery after giving off its final afferent glomerular branch, terminating by directly breaking up into a plexus round the convoluted tubules in the cortex corticis. Interlobular arteries have also been observed, which have terminated by breaking up directly into a plexus, in a deeper cortical area than this.

Fig. 3.—Glomerulus, showing the large size of the afferent compared with the efferent vessels, and the fact that the efferent vessel is not represented as a single trunk.

Fig. 4.—Direct nutrient vessel, coming from the trunk of an interlobular artery, which, without showing any evidence of a glomerulus, is breaking up into a plexus for tubular supply in the area. These vessels as seen are generally smaller than a corresponding afferent glomerular branch.

Fig. 5.—Structure of the glomerulus. The afferent vessel is seen dividing into a number of large branches, which are again subdividing into smaller ones. By a convergence of these branchings, the efferent vessel is formed. It can be seen that a partial destruction of a glomerulus need not necessarily result in a complete loss of function and consequent atrophy of the tubule associated with it.

Fig. 6.—Twin glomerulus. The afferent vessel in this case is seen to divide before entering Bowman's capsule, with the result that the glomerulus is practically divided into two separate halves. This appearance was occasionally observed, generally in sheep.

early stages of hydronephrosis, a noticeable increase in size is frequently observed, together with an occasional atrophic variety, to be described later.

AFFERENT GLOMERULAR VESSELS

The afferent glomerular vessels have a two-fold source of origin; i. e., in both the interlobular and the arcuate arteries. Afferent vessels originating from the arcuates generally run a longer course than those arising from the interlobular arteries. In the latter case, the afferent vessels coming off nearer the base are frequently longer than those originating nearer the termination of the vessel.

EFFERENT GLOMERULAR VESSELS

The efferent glomerular vessel, which is constituted by the reuniting of the loops forming the glomerulus, is usually single but may be subdivided so that more than one efferent glomerular vessel emerges from the capsule (Fig. 3). In size, it is smaller than the corresponding efferent vessel (Fig. 3), and it generally branches almost immediately on leaving the capsule (Fig. 7).

These efferent glomerular vessels may be classified under different headings according to the varying characteristics displayed in different situations. In order fully to comprehend this classification, the kidney must be arbitrarily divided into the following zones: cortex corticis, cortex proper, corticomedullary zone and medulla. Each of these zones has its own distinctive efferent vessel.

Subcapsular Type.—The cortex corticis, the most superficial portion of the cortex, is devoid of glomeruli, which are replaced in this area by convoluted tubules. The efferent vessels from the glomeruli, lying in close apposition to the cortex corticis and representing the terminal glomeruli supplied by the interlobular arteries, pursue an outward course and terminate by dividing into an extremely dense ramification around the convoluted tubules in this region. These are classed as the subcapsular type of efferent vessel (Fig. 1).

Cortical Type.—The cortex proper is supplied by the typical efferent glomerular vessel. This vessel, on leaving the glomerulus, runs in a direction more or less at right angles to the longitudinal axis of the interlobular artery from which the corresponding afferent vessel arose, and after a very short course, rapidly subdivides into an extensive net-work for the supply of the tubules in the locality (Fig. 7).

Corticomedullary Type.—The corticomedullary zone, which represents that portion of the cortex in close relationship to the medulla, has its characteristic efferent vessel, though the cortical type of efferent may also be found in this region. This variety combines the features seen in the zones above and below. On leaving the glomerulus, the

efferent vessel immediately subdivides into two distinct divisions. The upper of these behaves exactly as a cortical type of efferent, splitting up to supply the tubules in the cortex. The lower division pursues a downward course among the collecting tubules, forming arteriae rectae of the medulla (Fig. 8). The corticomedullary efferents may show further distinction as they are compared in different areas of the corticomedullary zone. In the portion nearer the cortex, the main part of the divided efferent goes to form the cortical type of efferent (Fig. 8), but when the medulla is approached, this arrangement is reversed, till almost the entire efferent runs down to the medulla as arteriae rectae (Fig. 9).

The medullary type of efferents originate from those glomeruli in intimate contact with the bases of the pyramids. These vessels generally leave the glomerulus as a single vessel, though occasionally it appears that a subdivision has occurred before leaving the capsule, and they run a direct course downward between the collecting tubules of the medulla, forming arteriae rectae (Fig. 10). A further description of their characteristics will be given in the account of these vessels.

ARTERIAE RECTAE

The vast majority of the arteriae rectae found in the mammalian kidney arise directly as efferent vessels from glomeruli (Fig. 11). The glomeruli supplying these efferents are situated in the medullary and corticomedullary zones of the cortex. No straight vessel arises from a glomerulus in areas more peripheral than these. Most arteriae rectae arise from glomeruli in close proximity to the bases of the pyramids, while a smaller proportion originate from those in the corticomedullary region.

The mode of distribution of the efferents forming straight vessels is very characteristic and typical of all such vessels. The main efferent runs for a distance and then subdivides and resubdivides, until from a single original vessel numerous arteriae rectae are produced, all of which retain practically the same caliber as the parent vessel. Arteriae rectae are found in greatest numbers in that region of the medulla where the tubules are most numerous, i. e., at the base of the pyramid. As the collecting tubules approach the apex of a pyramid, they converge to form the ducts of Bellini. With the decrease in number of the tubules, the arteriae rectae undergo a corresponding decrease by forming terminal loops around their associated tubules (Fig. 12). These loops reunite to form the venae rectae. The remaining arteriae rectae, which are comparatively few in number, continue on among the ducts of Bellini to the apex of the pyramid, where a terminal anastomosis is formed, through the branchings of which an anastomosis

Fig. 7.—Cortical type of efferent vessel, the most typical form of efferent glomerular vessel, found chiefly in the cortical zone of the kidney. The efferent vessel presents two characteristics: it is smaller in caliber than the corresponding afferent vessel, and its course lies more or less at right angles to the plane of the interlobular artery from which the afferent vessel arose.

Fig. 8.—Corticomedullary type of efferent glomerular vessel, with its double mode of distribution. The lightly stained branch is running down to the medulla to form arteriae rectae, while the two more darkly stained branches have a cortical distribution. This appearance is found in the more superficial part of the corticomedullary zone.

Fig. 9.—Two glomeruli in the deeper corticomedullary zone. The efferent vessels in their distribution are supplying two distinct areas. The upper branch is acting as a cortical type of efferent, supplying the tubules in the deeper cortical zone, while the lower, larger branch is running down among the collecting tubules of the medulla as a straight vessel. This appearance is characteristic of the corticomedullary type of efferent vessel.

Fig. 10.—Medullary type of efferent. The origin of the arteriae rectae, as efferent glomerular vessels, is well seen here. These glomeruli are in immediate contact with the bases of the pyramids so that the entire efferent vessel is given up to medullary supply (medullary type of efferent). The method of subdivision and the manner in which these vessels retain practically their original caliber may be noted.

is probably created between the anterior and posterior divisions of the renal artery (Fig. 13).

Vessels that may be regarded in a sense as arteriae rectae (since they have a medullary supply) arise from the lower ramifications of the plexus surrounding the tubules in the deepest cortical zone, and proceed for a short distance downward among the collecting tubules of the medulla (Fig. 14). These vessels do not play a very large part in the medullary blood supply.

Occasionally, what at first sight has appeared as a straight vessel arising directly from the concavity of an arcuate artery has been observed, but on careful examination a rudimentary glomerulus could invariably be made out in its course. Figure 15 is a good example of such a vessel. With the exception of an atrophied appearance of the glomerulus, the efferent vessel behaves exactly as a typical vessel of that locality by breaking up to form (arteriae rectae) straight vessels. Arteriae rectae arising directly from an arcuate or interlobular artery have never been demonstrated clearly enough to justify a belief in their existence. Numerous instances closely simulating such a phenomenon have been seen; but on careful and unbiased examination they have failed to prove convincing. On one occasion, a small glomerular-bearing artery arising from the concavity of an arcuate was seen to pursue a medullary course for a short distance and then apparently terminate directly by breaking up into arteriae rectae. In view of the number of sections examined, the fact that this could only be demonstrated on one occasion makes it rather doubtful that such is actually the case, and if so, it is certainly to be regarded as exceptional (Fig. 16).

VENOUS SYSTEM

In the renal vasculature, there is one outstanding feature presented in the venous system which is not exhibited in the arterial, that being the free anastomosis taking place between neighboring veins. The cortical branches of the renal artery do not anastomose until the efferent glomerular vessels are reached. Each individual branch supplies a definite area of renal tissue. Should this particular branch be obstructed, the corresponding area will be practically deprived of its arterial supply. At this point, it might be well to state that the terminal ramifications of the renal artery are not end-arteries. As experimental proof of this, one may divide the anterior and posterior divisions of the renal artery and, after tying a cannula into the former, irrigate it with physiologic sodium chlorid or Berlin blue solution, following which little difficulty will be experienced in obtaining a return flow by way of the latter. If a thin suspension of barium sulphate is substituted for the normal salt, or the dilute Berlin blue solution, this return flow cannot be established; which is explained by the fact that the coarse

Fig. 11.—Arteriae rectae: a typical example of the origin, appearance and distribution in the mammalian kidney. The complete absence of any suggestion that these vessels are arising directly from the larger trunks, i. e., the arteriae rectae verae as described and taught, may be noted.

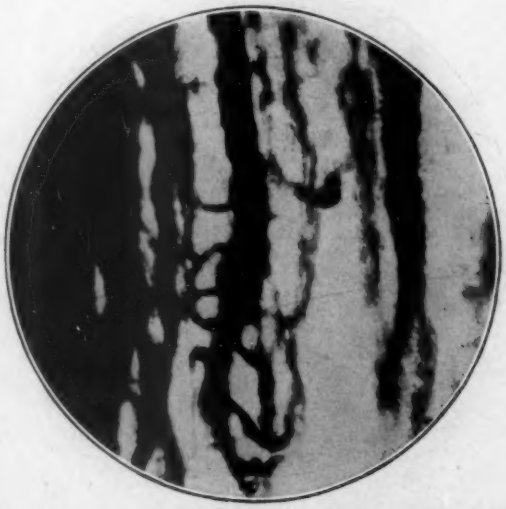

Fig. 12.—High power photomicrograph of the arteriae rectae of the medulla, showing the minute terminal loops surrounding the collecting tubules. By convergence of these loops, the venae rectae are formed.

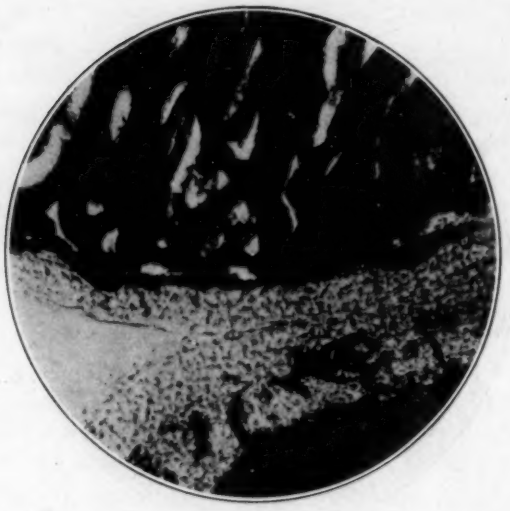

Fig. 13.—Terminal plexus formed by the arteriae rectae in the medulla. The mucous membrane covering the apex of the pyramid is seen resting in direct contact with the mucous membrane of the pelvic wall, the capillary blood supply of which can be seen immediately beneath it.

Fig. 14.—An interlobular artery taking origin from a larger arcuate trunk in the corticomedullary zone. The chief point for observation is the arrangement of the plexus formed by the efferents from the glomeruli in the lower cortical region. Branches from this plexus are seen running downward to supply the tubules in a limited area of the medulla at the bases of the pyramids. These vessels, though numerous, especially in the human being, do not run an extensive course and are not to be regarded as true arteriae rectae.

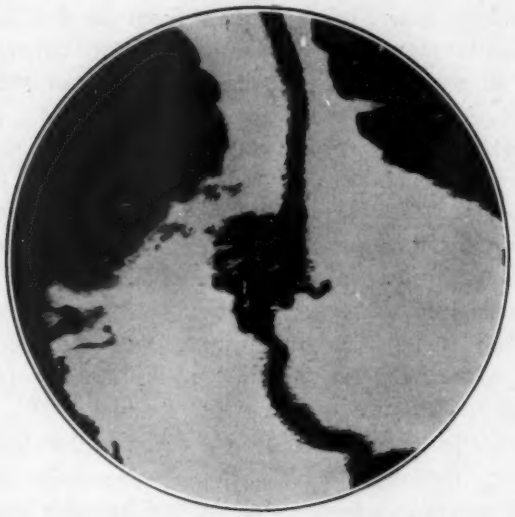

Fig. 15.—Atrophic glomerulus. The size may be estimated by comparing it with two normal glomeruli seen on either side of it. The additional points will be observed: (*a*) it is more oval and attenuated than the normal glomerulus; (*b*) the glomerular loops are relatively few in number and very coarse; (*c*) the afferent and efferent vessels enter and leave at opposite poles. All these features are significant of a cessation of function and absence of an associated tubule.

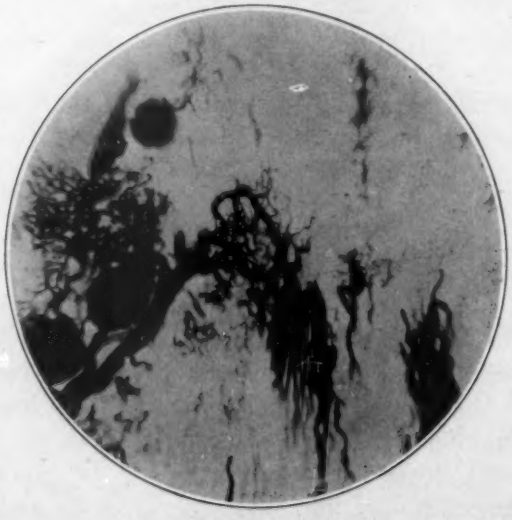

Fig. 16.—The one example obtained during the investigation of a glomerular-bearing artery apparently terminating by breaking up directly into arteriae rectae (arteriae rectae venae).

particles of barium sulphate plug the glomerular loops, thereby preventing any through flow. It may be seen from this that the anastomosis is a post-glomerular one. The actual site where this phenomenon occurs seems to be in the efferent glomerular plexus of the cortex and in the medulla, chiefly at the apex of the pyramid. At this point (Fig. 13), there is an anastomotic network formed between the arteriae rectae of both anterior and posterior divisions of the artery. A further interesting feature which has a decided bearing on this point is the fact that the renal circulation cannot be reversed. If the renal artery is irrigated with physiologic sodium chlorid solution, a ready return may be obtained from the vein; if this procedure is reversed and the renal vein is irrigated in the same way, not a drop can be recovered from the artery, even though the pressure is increased far beyond the blood pressure, till rupture of the organ results. This fact may be established clinically by anaesthetizing a rabbit and exposing a kidney together with its pedicle. If a ligature is now applied to the renal artery and this vessel is subsequently divided between the ligature and the kidney, there will be no hemorrhage from the free end.

The renal venous system as seen in mammalian kidneys may be classified under two headings: (1) the internal drainage type and (2) the internal and external drainage type. The internal or deep venous drainage as seen in the human being is the one characteristic of most mammals. In these, the second type is represented in a rudimentary way in the stellate veins seen on the surface of the kidney. The combined internal and external venous systems are well illustrated in the cat.

Vessels corresponding to the larger subdivisions of the renal artery are to be found in the venous system, i. e., interlobar, arcuate and interlobular veins, together with venae rectae.

INTERLOBULAR VEINS

These vessels are to be found running a similar course to the corresponding arteries, to empty into the arcuate veins. They may take origin from a peripheral stellate or from a venous plexus situated in the cortex corticis. As they descend through the cortex, they are reinforced by blood drawn from a venous plexus immediately surrounding them (Fig. 17). Into this plexus flows the blood derived from the efferent glomerular vessels supplying the convoluted tubules. The interlobular veins open into the convexity of the arches formed by the arcuate veins, which in the venous system form a series of anastomosing arcades much more pronounced than those seen in the arterial system. Into the concavity of these arches open the venae rectae of the medulla (Fig. 18).

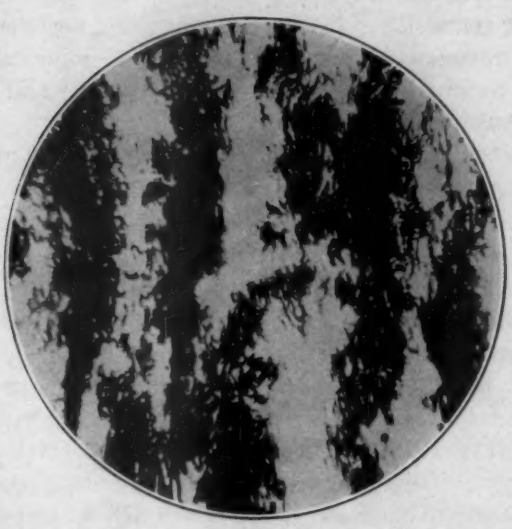

Fig. 17.—Venous injection, kidney. Here are seen the capillary venous plexus situated in the cortex of the kidney. The interlobular veins are completely surrounded by these plexuses and are running a more or less parallel course, to open at a lower level into the arcuate veins.

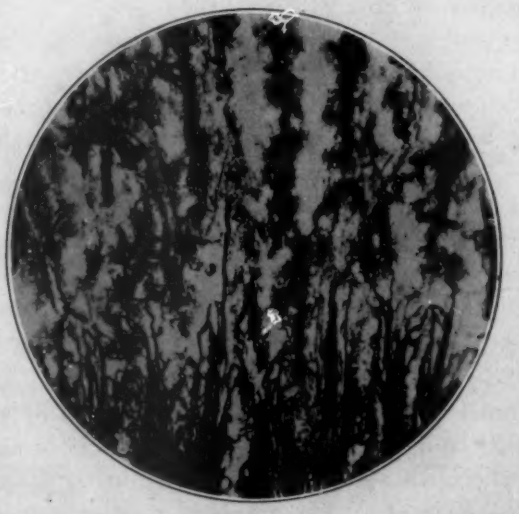

Fig. 18.—Low power photomicrograph of a venous injection, showing areas of both cortex and medulla. The interlobular veins surrounded by their capillary plexuses are seen in the former, together with the venae rectae opening into the interlobular and arcuate veins in the latter.

The Venae rectae take origin from the fine loops formed by the arteriae rectae round the collecting tubule of the medulla, and running in a cortical direction among these tubules open into the concavities of the arches formed by the arcuate veins (Fig. 19) and into the bases of the interlobular veins.

The interlobar veins are formed by the convergence of the arcuates, which in turn unite to form the renal vein.

COMMENT

The coarser vascular arrangement of the kidney will not be described in this article, but will be dealt with in a subsequent contribution. It has already been so well demonstrated by Gross,[5] who employed for this purpose bismuth injection and roentgenography, together with Huber,[6] Brodel [10] and other observers, using corrosion methods, that little is left for discussion. All the cortical branches of the renal artery are end-arteries up to the efferent glomerular plexus. There are branches of the renal artery which are not end-arteries, a fact demonstrated by the return flow obtained from the posterior division of the renal artery, following irrigation of the organ with physiologic sodium chlorid solution through the anterior division. This anastomosis seems to take place in the efferent glomerular plexus of the cortex and in the medulla, chiefly through the branches of the terminal plexus situated at the apex of the pyramid.

Of direct nutrient vessels arising from interlobular arteries within the cortex but not associated with a glomerulus, two varieties have been observed, which contradicts Bowman's original theory that all the blood leaving by the renal vein must have first passed through a glomerulus.

1. An interlobular artery may terminate directly by breaking up into a capillary plexus for the supply of the tubules in that area (Fig. 2). This, while not very uncommon, must not be regarded as the usual mode of termination of an interlobular artery. A somewhat similar condition is seen when an interlobular artery ends as a perforating capsular artery.

2. Direct nutrient vessels arising from the trunk of an interlobular artery during its course through the cortex have been seen most commonly in the sheep, though their appearance in the human being has also been noted (Fig. 4). These vessels vary in size, although generally smaller than a corresponding afferent glomerular vessel. They run a short course and then split up into a capillary plexus similar to

10. Brodel, Max: Intrinsic Blood Vessels of the Kidney and Their Significance in Nephrotomy, Johns Hopkins Hosp. Bull., January, 1901, pp. 10-13; Proc. Ass'n Am. Anatomists, 1901.

Fig. 19.—Venous injection, kidney. A section of the corticomedullary junction of the kidney showing the venae rectae. These vessels run a somewhat similar course to the arteriae rectae and open into the arcuate and bases of the interlobular veins.

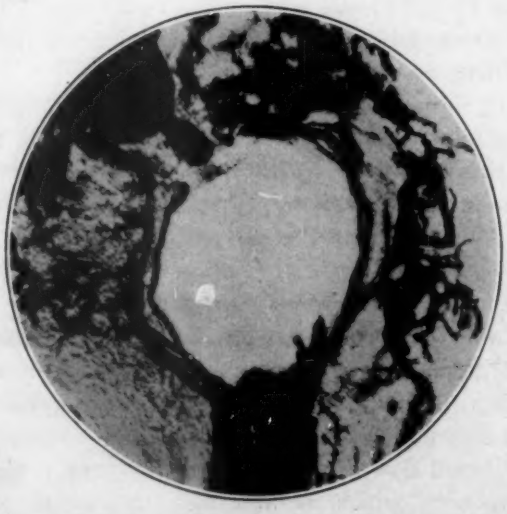

Fig. 20.—Group of arteriae rectae, some of which are closely encircling the gap left by the removal of the trunk of a large vessel. It appears that some of the arteriae rectae are originating from this vessel and were attached to it before it was torn out. This is not the case; for had the vessel remained, a definite gap would have been seen between it and the site where these vessels appear to arise from it. Also had a thick section of this area been stereoscopically viewed under a binocular microscope, all the vessels of the group would have been seen to encircle the large trunk, in the manner of the ones already doing so.

that formed by the efferent glomerular vessels in the locality. Vessels of this type have been observed which never showed the slightest evidence of a glomerulus throughout their course, a reverse condition to that noted in certain varieties of arteriae rectae.

ARTERIAE RECTAE

The accepted teaching with regard to the arteriae rectae is that there are two distinct groups: (1) arteriae rectae verae and (2) arteriae rectae spuriae.

1. The arteriae rectae verae are described as originating directly from the concavity of the arcuate arteries and the bases of the interlobular arteries. From this origin, without any association with a glomerulus, they stream down to supply the collecting tubules of the medulla. Although a large number of sections made from different varieties of mammalian kidneys have been examined with this very point in view, one cannot conscientiously say that any such vessel has ever been observed. Numerous instances of what at first sight appeared to be arteriae rectae verae were observed to arise from the concavity of an arcuate artery; but on closer inspection these invariably showed the presence of a glomerulus. These glomeruli were in most cases extremely small (Fig. 15) and appeared to be atrophic. They represent the "atrophic glomeruli" of Huber[8] and the "retia miribilia renum nova" of Golubew.[11]

In explaining these atrophic glomeruli, their following characteristics are to be taken into consideration: (*a*) they are always found in close apposition to the medulla; (b) they are always small and atrophic, signifying a diminished function; (*c*) the glomerular loops are coarser and fewer in number than the normal, and (*d*) the afferent and efferent vessels enter and leave at opposite poles and not at one point, as generally happens in the normal glomerulus.

In view of the foregoing facts, the most obvious explanation seems to be that the glomerulus is neither surrounded with a capsule nor associated with a tubule. In this case, its glomerular function has ceased as such and it now merely serves as a connecting link for the continuance of blood flow from afferent to efferent vessels.

Others were seen which at first sight resembled arteriae rectae verae. If thin sections of an injected piece of renal tissue are made in such a manner that they show a cross-section of an arcuate artery in the corticomedullary zone, it will frequently appear that a group of arteriae rectae verae is springing directly from it (Fig. 20). At the

11. Golubew: Ueber die Blutgefässe der Niere der Säugetiere und des Menschen. (Gives complete bibliography to date.) International Monatschr. f. Anat. u. Physiol. **10**:541-598, 1893.

same time, it will be noticed that several arteriae rectae belonging to the same group are streaming round the vessel, in close relationship with it. If further serial sections immediately above and below this were made and examined, it would be found that the entire group behaved in a similar manner. Again in Figure 20, the actual cross-section of the arcuate artery itself is missing, which would confuse the observer who imagined these straight vessels were arising directly from it. However, had the main trunk remained, an appreciable interval would have been observed between it and these arteriae rectae which appear to be rising from it. By the use of the binocular microscope and stereoscopic examination of thick sections, this source of error is entirely eliminated.

Figure 16 represents the one instance found of a glomerular-bearing artery arising from an arcuate and running in a medullary direction, which, having given off a few afferent glomerular branches, seems to be terminating by directly breaking up into arteriae rectae verae. As this section is very thin and no others were made in immediate relationship, conclusive deductions cannot be drawn, especially in view of the fact that duplication has not been possible.

2. Arteriae rectae spuriae represent the main and almost entire blood supply to the medulla (Fig. 11). These vessels arise as efferents from glomeruli situated for the most part directly in contact with the bases of the pyramids, although a smaller proportion originate as efferents from glomeruli in the more peripheral corticomedullary zone.

The medulla receives a small additional blood supply from the lower branches of the plexus formed by the efferent glomerular vessels surrounding the tubules in the deepest cortical zone (Fig. 14). Owing to their smallness, these vessels cannot be considered as justifying the title arteriae rectae.

CONCLUSIONS

1. The coarser distribution of the renal vessels conforms to the generally accepted teaching.

2. The afferent glomerular vessels vary in length and have two sources of origin: (*a*) the trunks of the interlobular arteries and (*b*) the arcuate arteries.

3. Glomeruli consist of a ramification of the afferent vessel converging to form the efferent within Bowman's capsule. They may vary in size, there sometimes being twin glomeruli and sometimes an atrophic variety.

4. The atrophic or aborted glomeruli are found in close proximity to the medulla and represent glomeruli devoid of a capsule and whose specific function has ceased. They now merely serve as conducting vascular channels from the afferent to efferent vessels.

5. There are four distinct types of efferent vessels: (*a*) subcapsular, (*b*) cortical, (*c*) corticomedullary and (*d*) medullary. Each of these has its own particular mode of distribution.

6. The arteriae rectae originate as efferent vessels from glomeruli situated chiefly in close relationship with the medulla, though a smaller percentage arise as efferents from glomeruli in the corticomedullary zone. These vessels form most of the blood supply of the medulla, though a small amount is drawn from the lower branches of the plexus formed by the efferent vessels in the deepest part of the cortex.

7. The arteriae rectae verae do not exist as taught. Such vessels may be observed, but their presence is extremely exceptional.

8. Direct nutrient vessels do exist and may be seen in two situations: (*a*) an interlobular artery may end by directly breaking up into a terminal ramification surrounding the convoluted tubules of the cortex (a modification of this is seen in the perforating capsular artery); or (*b*) branches are given off from the trunks of the interlobular arteries, which, after pursuing a short course and showing no evidence of a glomerulus, break up into a plexus supplying the tubules.

9. All the branches of the renal artery are not true end-arteries, as a return flow may be obtained by way of the posterior division when the organ is irrigated with physiologic sodium chlorid solution through the anterior division of the artery.

10. The renal circulation is irreversible.

All findings have been actually observed and are individually substantiated by direct photographs.

PROBABLY XANTHOMATOSIS →

MULTIPLE MYELOMAS OF CHILDREN *

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CHICAGO

The occurrence of multiple tumors of the skeleton has been recognized for many years, especially in adults. The frequency of multiple myeloma is either increasing, or the clinical diagnosis and reports of cases are being made more frequently.

Previous to 1916, Martini [1] collected only 204 cases of this type of multiple bone tumor reported in the literature. All of the cases reported were in adults, the youngest patient being 24 years of age.

As two cases of multiple myelomas of children have come under my observation, I feel that they should be recorded in the literature.

Harbitz [2] reported two cases of multiple bone tumors involving the cranial bones, ribs, sternum and vertebrae, which were associated with enlargement of the liver and spleen. He suggested the name, myeloerythroblastoma for these tumors because of their microscopic structure.

The term multiple myelomas was first applied in 1876 by Rustizky to a case of primary multiple tumors of the skeleton, which he believed originated from the blood forming cells of the bone marrow. There is still much uncertainty as to the true classification of these tumors, although most observers have agreed that they are derived from the blood forming cells of the bone marrow and are related to the primary diseases of the lymphatic hemapoietic apparatus. This condition is described as a specific malignant tumor of the bone marrow originating in different parts of the marrow system at approximately the same time from a single cell type and characterized chiefly by multiple foci of origin, the individual tumors springing from certain primitive cells and giving a uniform and specific structure composed of plasma cells or their derivatives, which rarely give metastases but often do produce an albuminuria and terminate fatally.

Various theories as to the etiology have been advanced, but none have been established. The leading theories as to the origin are those given for all neoplasms: (1) trauma, (2) irritation and (3) infection.

It is interesting to note that most of the diagnoses of the reported cases were made at necropsy, and that in the cases in which a diagnosis

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* Preliminary report read at a meeting of the Chicago Orthopedic Club, April 13, 1923.

1. Martini: Policlinic **23**:382, 1916.

2. Harbitz, Frances: Norsk Mag. f. Lægevidensk. **84**:211 (March) 1923.

was made previous to death, the various clinicians tried to base the cause on some injury, a history of which can always be elicited by direct questions even though the injury may have been trivial or may have occurred years before the onset of the symptoms. Some patients gave a history of prolonged irritation, as by a rubber tube pressing on the ribs in the draining sinus of a thoracic empyema; while others cited foci of infection, such as alveolar abscesses around the roots of devitalized teeth, or a result of some acute infections such as erysipelas and typhoid fever.

The incidence of the myelomatous tumors during the adult life is given as 60 per cent. between the years of 40 and 60, and 26 per cent. after 60 years of age. Seventy-six per cent. of cases occur in the males.

The points of predilection are in bones having a relatively large amount of cancellous bone or red bone marrow, such as the vertebra, sternum, ribs, clavicle, skull, scapula, ilium and rarely the ends of the long bones. However, in the following cases, the ends of the long bones are involved, which may be explained by the fact that in this location there is a relatively larger amount of red bone marrow in children, which may exist to a greater age at the ends of the long bones, as in the cancellous bones.

The tumors are confined to the bones, but occasionally they become extraskeletal. They entirely replace the normal red bone marrow in the involved areas, and because of their diffuse extension they have a corroding action on the bone cortex itself, until they are no longer covered by even a thin shell of bone but become extra-skeletal tumors. The bones become fragile, and hence there may be many pathologic fractures, with peculiar deformities. For example, if the bodies of the vertebrae become involved, the deformity present is that of a sharp posterior angular deformity simulating Pott's disease. The sternum presents an elongated cylindrical tumor mass. The ribs and clavicles have fusiform swellings, while the long bones have an increase of circumference in the portion involved, and if there are any spontaneous fractures, various atypical deformities result.

The individual tumor appears as a soft gelatinous vascular growth, red or reddish gray, in which dark hemorrhagic areas are common. There is no tendency to new bone formation, and rarely are there metastases in the lungs, liver and other viscera.

MICROSCOPIC FINDINGS

There are a variety of types of myeloma as determined on the basis of the histologic characters of the tumor cells, which originate from the myeloblast. Myelomas are composed of large, spherical or polyhedral cells, which lie without definite arrangement in a fine connective tissue

stroma, separated from each other by a formless ground substance. The stroma contains many thin-walled vessels, most of which are composed of only one layer of endothelial cells. Hence, hemorrhages are prone to occur. The neoplasm may have a poor vascular supply, though areas of necrosis are rare in the tumor. Bone is not found in the new growth, apparently because of the destructive or lytic action of the tumor cells. Occasionally, there are many giant cells or osteoclasts, which may have destroyed bone or prevented its proliferation.

The types of myeloma generally accepted on the basis of the predominating cells are:

1. Myeloblastomas, or those in which the myeloblast is the essential cell. It occurs as a spherical cell about the size of a large lymphocyte with abundant nongranular, lightly basophilic cytoplasm and a large vesicular nucleus. Its nuclei are weakly basophilic and possess a fine, filamentous chromatin net-work, in which lies the acidophilic nucleolus.

2. Lymphocytomas or those which have a preponderance of lymphocytes. In the early stages, these were called lymphosarcoma. Herrick and Hektoen [3] reported a case of this type with tumor masses in the liver and spleen.

3. Neutrophilic granules in cytoplasm. These may be regularly distributed as in the normal neutrophilic myelocyte, or the cells may contain huge and irregularly shaped pigment clumps. Such cells are considered atypical derivatives of the neutrophilic myelocyte.

4. Erythroblastomas, made up of cells containing hemoglobin and thus resembling erythroblasts.

5. Plasmocytomas consist of plasma cells which are irregularly oval in shape and the size of a large lymphocyte. The protoplasm takes a deep basophilic tint in its peripheral portion but has a clear space around the eccentrically placed nucleus. The latter is vesicular in type, with dark chromatin clumps arranged peripherally just within the nuclear membrane, and contains an intensely staining acidophilic nucleolus. This type was originally described by Unna.

The first three tumor types are true multiple myeloma. Multiple myelomas belong to that group of tumors that are composed of cells derived from the primary mesenchymal *Wanderzellen* and are closely related to the leukemias, chloromas and other diseases of the lymphatic hemapoietic systems.

The symptoms depend on the size, number and distribution of the tumors and their subsequent deformities.

The onset is usually insidious and periodic, with pain which is deep seated, and localized bony tenderness, which is more acute with motion

3. Herrick and Hektoen: Med. News **65**:239, 1894.

of the part either actively or passively. It is worse at night. The multiple involvement of bones arouses the suspicion of metastases. The pain is often referred, as in Pott's disease, if the vertebrae are involved, because of pressure on the spinal nerves at their abnormal exits from the spinal column.

There develops a secondary anemia and emaciation. The blood usually shows from three to four million red cells, from 50 to 80 per cent. hemoglobin and from 7,000 to 15,000 white cells, with the normal proportion of the various kinds of leukocytes except for a slight increase in the percentage of transitional cells. Nucleated red cells are frequently found, and from 5 to 8 per cent. of myelocytes have been found in the blood by means of special stains, such as indophenol blue, but any marked changes in the blood picture speak against myeloma.

In 1845, Henry Bence-Jones reported a peculiar form of protein in the urine in a case in which at necropsy the ribs and vertebrae were found to be so decalcified that they could be cut easily with a knife.

This protein is precipitated from the urine when mineral acids are added, or from acid urine at 56 C. It dissolves at the boiling point and reappears on cooling.

This protein, which has been accepted as such an important diagnostic factor in multiple myelomas, is present in about 80 per cent. of the cases in which the pathologic diagnosis was made either postmortem or by biopsy. The urine in which it is found is usually highly acid and of a specific gravity of from 1.013 to 1.020. In the clinical cases of multiple myeloma with Bence-Jones proteinuria, the reaction is usually continuously present. However, temporarily, albumose is found periodically in the urine of patients suffering from other cachetic or febrile conditions. Chittenden believes that the true Bence-Jones proteinuria results from the action of enzymes from the tumor cells on the protein of the blood.

Dr. Ludvig Hektoen [4] has called attention to a specific precipitin for Bence-Jones protein, which may be present in either the blood or the urine, and which seems to be more specific for the higher dilutions.

The presence of Bence-Jones protein in the urine is said not to be pathognomonic of myelomatous tumors, nor is myelomatosis always attended by Bence-Jones proteinuria.

Roentgen rays reveal multiple areas of medullary rarefication with varying amounts of erosion of the cortex, from slight thinning to the presence of a thin shell covering or complete disappearance, which results in a complete perforation with rather sharply punched out

4. Hektoen, Ludwig: Specific Precipitin for Bence-Jones Protein, J. A. M. A. **76**:929 (April 2) 1921.

margins. In adults, the bones are more generally involved, a honeycombed appearance resulting; while in children, the tumors become much larger. In adult cases, with involvement of many vertebrae, there has been such an extensive absorption of mineral salts that the shadows of the intervertebral cartilages stand out distinctly as compared with the dim outline of the form of the vertebrae themselves. In one of the following cases, there was involvement of segregated vertebrae, the bodies of which revealed a diminution of density throughout. There was some angulation of the bodies forward or laterally, depending on the location and extent of the tumor growth.

Complications are frequent. If the vertebrae are involved, we may have the development of transverse myelitis, with a resulting spastic paraplegia. This condition may be the first symptom complex. With the skull involved and with the inner table of bone eroded, we may have all the symptoms of a brain tumor or increased intracranial pressure with headache, nausea, projectile vomiting, choked optic discs, exophthalmos and meningeal irritation of that portion of the brain adjacent to the tumor.

Pathologic fractures with various deformities may unite if completely fixed early, only to be refractured with the further erosion of the advancing tumor.

The course of the disease is from six months to two years, but patients have been known to live five years after the onset of the symptoms.

Pneumonia is most often the terminal factor.

DIFFERENTIAL DIAGNOSIS

Myeloma is to be differentiated by its multiple primary lesions or by factors in its occurrence. It is composed of a distinctive uniform cell type, with a lesser degree of heteroplasia. These cells have a specific and marked ability to erode bone by lacunar absorption without producing a reparative reaction on the part of the bone. They possess little ability to metastasize in spite of their local destructive character.

It is difficult to distinguish chloroma from multiple myeloma microscopically, but macroscopically the former presents a characteristic iridescent, opalescent greenish color when the fresh specimen is cut.

Cysts involve the ends of long bones and show areas of rarefication with well defined bony outlines.

Enchondroma presents areas of rarefication, with linear striations extending from the epiphyseal lines into the shaft of long bones.

Osteomalacia usually occurs in women who are pregnant. There are diffuse pains, but few fractures occur. The pathologic process is decalcification rather than erosion.

Myeloid sarcoma seldom attacks the ribs and vertebrae, but usually occurs in the ends of long bones. Spindle-shaped cells or cells with elongated nuclei are present. Reformation of bone takes place.

Treatment has not thus far altered the course of this fatal multiple tumor.

However, recumbency on a Bradford gas pipe frame or in a posterior molded shell gives much comfort to the patient. Of course, in pathologic fracture, the long bones must be immobilized as in any other fracture.

Radium and high voltage roentgen rays are said to diminish the pain in the lesions.

REPORT OF CASES

CASE 1.—*History.*—W. M., American boy, white, 12½ years of age, admitted to the orthopedic service of the Children's Memorial Hospital, Oct. 17, 1922, with the complaint that the back and shoulders were held stiffly when stooping. The onset in June, was rather sudden.

The patient was a full term normal infant at birth. The mother, who had pulmonary tuberculosis, died of influenza. The father was living, but had pulmonary tuberculosis, a "bad case." Two other children were well, having no limp, cough or pain in the chest, but were rather undernourished. Five aunts and uncles of the patient died of tuberculosis.

Seven years previously, before which time the child was perfectly well in every particular (had no cough, cold, sore throat, rheumatism or other known trouble) he was injured in an automobile accident. Dr. J. H. Walsh, the attending surgeon, reported that, on April 6, 1916, the patient, who was then 6 years of age, suffered from a compound comminuted depressed fracture of the skull and associated brain injuries. The larger fragments were decompressed (elevated), the smaller ones removed and the wounds drained. The patient left the hospital May 14. The wounds were healed, and there were no focal symptoms and no record of spinal injury was made. Gradually, he recovered completely. He was always active and well. The only abnormal thing noticed was that the child said, when getting up out of bed, he always had to thrust feet and legs out first; but he complained of no pain and could easily pick things up from the ground. In June, 1922, he would awaken several times from sleep, screaming with pain in the left knee, which would last but a moment or two and then disappear. He did not limp during the day. He tired easily and looked rather "sallow." He was taken to a dispensary for examination, especially because of his tuberculous family history, but he was pronounced well.

In July, he fell from a bicycle, injuring his spine and hips. He complained of pain in the back for some time, but gradually he grew able to be up and about. His back, bothered him considerably and when stooping he would hold his back stiffly and cautiously lower his body by flexing his thighs and knees. He had never since been able to bend his back forward to pick things off the floor.

Coincidently, there developed a "side" curvature of the spine, causing one of the shoulders to droop. This condition was progressive for a while and very bad, but it seemed to have improved recently. The pain in the knee, which had been present since June, was not accompanied by swelling or redness. Extreme motion seemed to be painful.

Ten days before admission, he vomited, after being nauseated. He had vomited several times since, being able to only retain orange juice and a little gruel. He vomited the last time the morning of his admission, forcibly and suddenly, as usual, almost without warning. He was very constipated. There was no pain in the abdomen.

Since the injury last July, he had complained of pain in the left side, not in the bones, but seemingly in the muscles, which had been almost continuous. While attempting to get out of bed the previous Friday, the patient says something "snapped" in the left hip and he has had pain in that hip since that time. His aunt noticed a definite swelling in that region immediately afterward. He never had worn casts. Urination was not painful or frequent.

Disease.—Denies all.

Fig. 1 (Case 1).—Tumors in both femora; pathologic fracture of left femur.

Physical Examination.—The patient was large and fairly well developed, but undernourished, mentally alert and attentive. His face was thin, with flushed cheeks and anxious expression. The lips were dry. He had a thick growth of straight brown hair. The shape of the head was normal. An old scar, well healed, 3 inches (7.5 cm.) long was noted in the occipital region. Otherwise, the findings were normal.

There was slight prominence of the left lower ribs in relation to the right. The chest was funnel-shaped; the sternum prominent. Expansion was fair, the right side lagging slightly. The panniculus was scant. The lungs were resonant throughout. The voice and breath sounds normal, with no râles.

The apex impulse was visible 2 cm. to the right of the nipple line in the fourth and fifth interspace. There was no bulging of the precordium. No thrill was felt. At the apex a soft short systolic murmur, not transmitted, was heard. Over the pulmonic area, there was a loud rough systolic murmur in the third interspace to the left of the sternum, not transmitted to the vessels of the neck. There was a marked sinus arrhythmia.

The abdomen was scaphoid, with no masses or tenderness.

The elbow jerk and Achilles, abdominal, and cremasteric reflexes were one plus, right and left. The knee jerks were two plus. All others were negative.

Motion was equal in the two lower extremities. A slight psoas spasm was present. There was prominence of the spines of the first and second lumbar vertebrae, with rigidity of the spine below. There is a tender palpable mass the size of a large walnut situated deeply to the right of the kyphos.

The provisional diagnosis was lumbar Pott's disease.

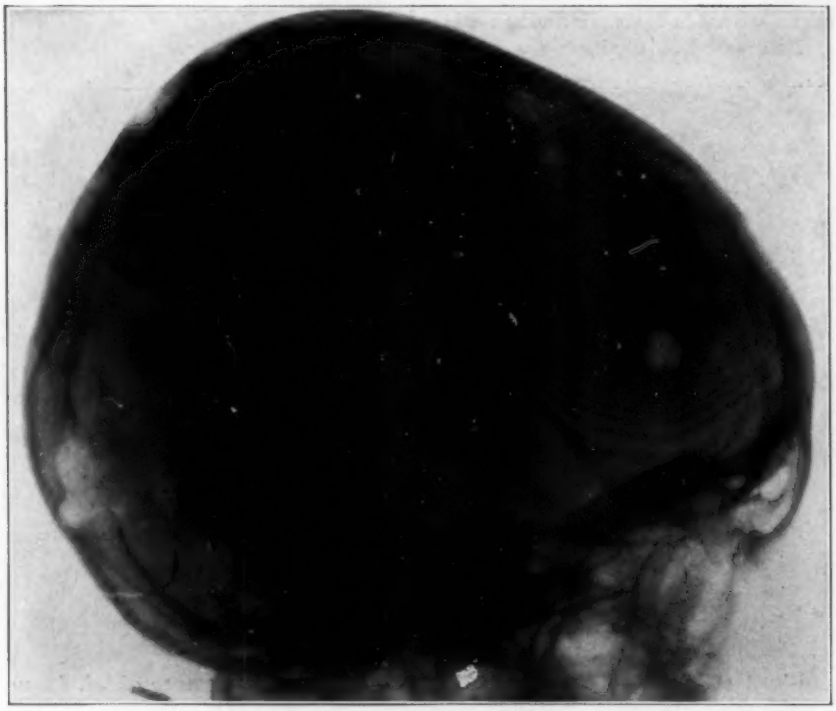

Fig. 2 (Case 1).—Multiple tumors of skull.

Course.—October 23: The patient was seen by Dr. Brennemann, who found: (1) inequality of pupils (left > right); (2) slight nystagmus; (3) Brudzinski sign (?)—rigidity of neck; (4) listlessness (since admission); (5) frequent vomiting and refusal of meals; (6) positive Babinski and Kernig signs. He expressed the opinion that the condition was beginning meningitis. Spinal puncture was not advised because of the location of the Pott's disease.

November 3: The patient complained of tenderness over the left greater trochanter and pain on motion of the left leg. The skin over this area was tense but not red. There was no fluctuation.

Projectile vomiting occurred from one to three times, October 27 and 29 and November 11 and 12. Epistaxis occurred November 1 and 3. A systolic murmur was heard, very loud and harsh in the second left interspace. A marked thrill was felt and heard in the same region.

Further diagnosis was congenital heart disease, patent ductus arteriosis (Gibson).

The pupils were persistently unequal. November 3, Dr. Hall examined the eye grounds and found them normal. The blood vessels were small and few. There were no choked disks.

November 6: The patient complained of excruciating pain over the outer side of the left thigh, just below the greater trochanter. The left leg was 1 inch (2.5 cm.) shorter than the right, and the circumference of the thigh near the groin on the left was 1 inch greater than on the right.

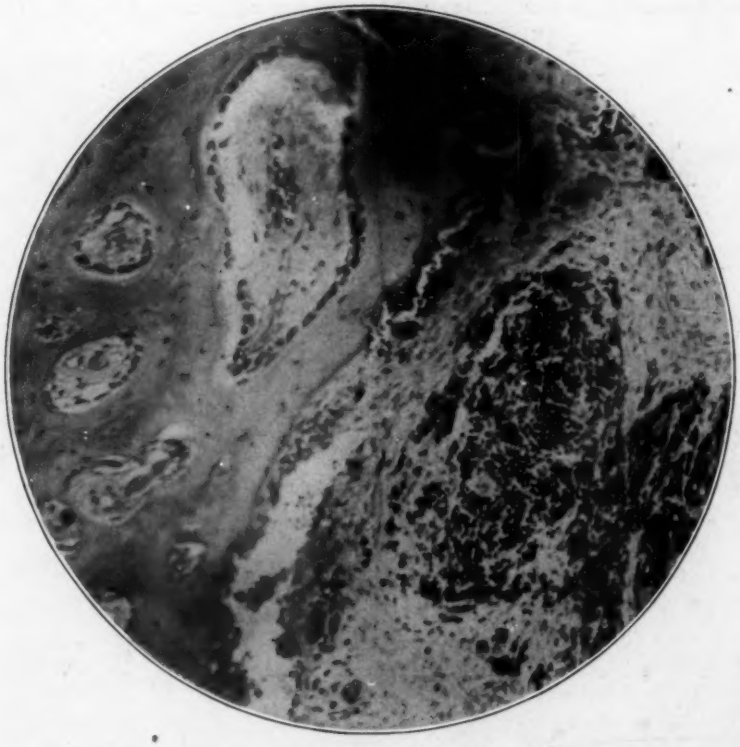

Fig. 3 (Case 1).—Photomicrograph of tumor tissue.

There was no involuntary muscle spasm at the left hip joint, but when the patient lay on his face, there was restriction to hyperextension of the left thigh, which was voluntary. There was a slight deformity of the upper lumbar vertebrae, shown by slight kyphosis. There was restriction of motion by an involuntary muscle spasm in this region. When the patient lay on his back, there was no psoas abscess felt in either lower quadrant. The pupils were equal and the knee jerks lively. No Babinski sign was elicited. The patient did not seem to have sufficient objective signs in the back to account for his subjective symptoms.

November 8: Roentgen-ray examination of the left leg (Fig. 1) revealed a medullary rarefaction in the upper 2 inches (5 cm.) of the shaft and a pathologic fracture just above the trochanter, with callous formation in the neck.

The hip was not involved. The lumbar vertebrae (second and third) showed destruction with angulation to the right. In the skull (Fig. 2) were numerous areas from the circumference of a pea to that of a nickel, of lessened density, described by Dr. Davis as areas of bone atrophy from pressure. A diagnosis of "malignant bone tumor" was made.

There was 1½ inches (3.7 cm.) shortening with greater deformity at the point of fracture, with crepitus and greater mobility at this point. The right knee jerk was markedly exaggerated. A short ankle clonus could be elicited, and there was a positive Babinski sign. It was thought that the patient would be more comfortable with the left leg immobilized, so we applied a long plaster spica (left) from the toes to the nipples.

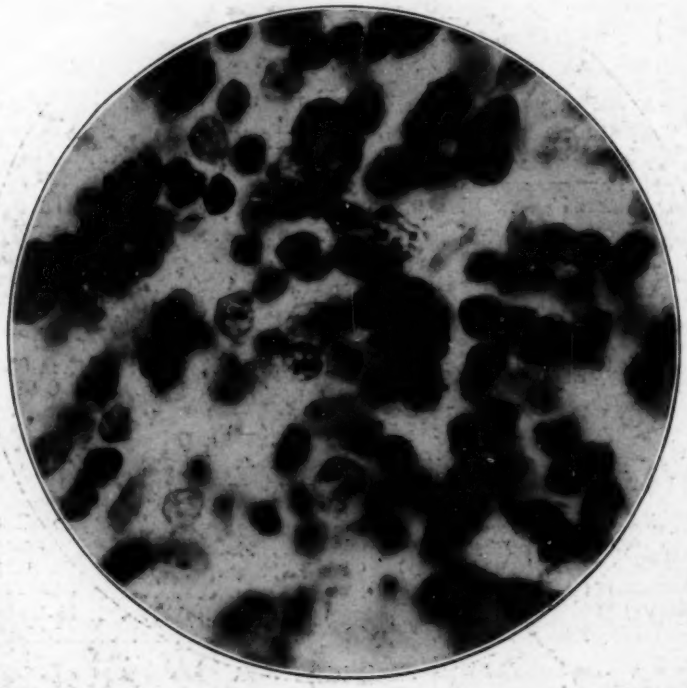

Fig. 4 (Case 1).—Photomicrograph (oil immersion), showing lymphocytic type of cells.

November 29: The Wassermann (blood) reaction was negative. An exploratory incision was made by Dr. Ryerson of the lesion of the femur for microscopic examination. Photomicrographs (Figs. 3 and 4) show lmphocytic type of cell predominated.

December 12: Dr. H. G. Wells diagnosed the bone section as myeloma.

February 21, 1923: The patient complained of pain in the right shoulder and a roentgenogram of the shoulder showed perforations of the scapulae (Fig. 5). The pain and swelling in the left knee were apparently subsiding. He had complained of headache the past two evenings and vomited breakfast in the morning.

March 10: The patient vomited. He complained of frontal headache.

March 24: The patient complained in the morning of rather severe headache. On examination, there was an oval swelling over the left forehead at the hair-line and extending into the scalp and down to the middle of the forehead. This swelling was painful but skin over it was not red, nor was there increased local heat. In the center of this swelling, there was a spot which was rather soft to the touch, and caused the patient to complain of a great deal of pain.

March 25: The swelling noted the previous day was becoming less noticeable, because of more diffuse swelling over the entire forehead. The headache was still complained of. There was also an indentation of the temporal bone on the left side just above the ear, which was tender to pressure.

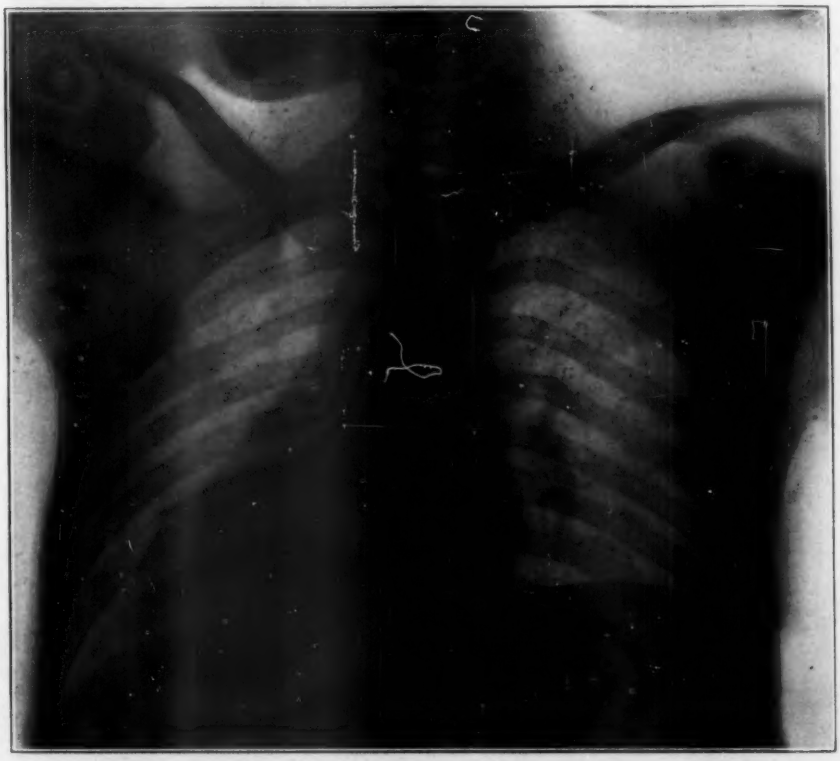

Fig. 5 (Case 1).—Showing perforations of scapulae, ribs and clavicle.

April 5: The patient complained of severe pain in the right thigh and knee and cried out. Morphin sulphate, one-sixteenth grain, was given to ease the pain.

April 5 (Dr. Hamill): All aspects of the patient's nervous system were now normal.

Other points in the clinical course were: (1) poor appetite; (2) little change in temperature from day to day (average 99.5 F.); (3) (Dr. Ludvig Hektoen) positive reaction with antiserum for Bence-Jones protein; chemical tests negative; (4) transillumination of sinuses negative; (5) constipation and frequent attacks of vomiting; (6) headache, stomachache and legache.

May 23: The condition of the patient had gradually become worse. Tumor masses which are palpable along the course of all the ribs had developed. The right femur had become tender and painful as the small tumor in its upper end had increased in size. Nodules and perforations of the skull had developed at the points of involvement shown in the roentgenograms of the skull (Fig. 2). The patient was developing slight bilateral exophthalmos.

Laboratory Data.—These findings are given in the accompanying tabulation.

Pirquet Tuberculin Tests

	Human		Bovine	
Date	24 hrs.	48 hrs.	24 hrs.	48 hrs.
10-21-1922	(+)	(++)		
1-25-1923	(—)	(—)	(—)	(—)
1- 6-1923	(—)	(—)	(—)	(—)
3-25-1923	(—)	(+)	(—)	(—)

Intracutaneous Tuberculin Test

(Human: $\frac{1}{1000}$ O.T., one drop.)

	Reaction	
Date	24 hrs.	48 hrs.
2-16-1923	(+)	(+)
4- 4-1923	(—)	(—)

Moro Test

(+) (+)

Urinalysis

Date	80-gr.	Reaction	Albumin	Sugar	Color	Sediment	Microscopic
10-23-22	1010	acid	trace	(—)	light amber	clear	1 hyaline cast
4- 6-23	1010	acid	(—)	(—)	light yellow	clear	

Blood Examination

Date	H.B.	Red Cells	White Cells
10-23-22	70	3,830,000	10,000
12-12-22	50	3,375,000	16,400
1- 6-23	44	2,864,000	15,600
3- 3-23		4,300,000	10,500
3-28-23	60	3,090,000	13,200

Differential Count

Date	Polymorphonuclears	Eosinophils	Small Lymphocytes	Large Lymphocytes	Transitionals
10-23-22	67		29		4
12-12-22	64		29	5	2
1- 6-23	70	3	20	7	
3- 3-23	51	3	34	10	2
3-28-23	62	2	25	4	7

Blood Wassermann Test (11-10-22)

Negative to { Acetone in soluble antigen; Cholesterinized antigen; Alcoholic antigen }

Blood Chemistry (4-4-1923; Dr. Hibbs)

(*a*) Nonprotein nitrogen 40 mg. per hundred c.c. of blood
(*b*) Sugar 62.5 mg. per hundred c.c. of blood
(*c*) Creatinine 1.4 mg. per hundred c.c. of blood.

Roentgen-Ray Examination.—This revealed lesions in many vertebrae, especially the sixth cervical, second, fifth and seventh dorsal and second lumbar. The right scapula (Fig. 5) had two definite tumor lesions as is shown by the perforations. Practically all the ribs were involved. The skull contained characteristic lesions as did the ilium, pubic bone and ischia. The knee (Fig 7) was involved by lesions at the lower epiphyseal line of the left femur and the

Fig. 6 (Case 1).—Left hip; taken four months after Figure 1.

upper end of the left tibia. The right femur had a small tumor in the upper end (Fig. 1).

Outcome.—During the stay in the hospital, of about one year, the disease became progressively worse. Weakness, emaciation and anemia gradually increased, with the occasional occurrences of pathologic fractures of the long bones, which necessitated the administration of opiates for the relief of pain.

The bones most involved were: the ends of the long bones, especially the upper and lower ends of both femora; the upper ends of both fibulae, the upper ends of both tibiae and humeri, the skull, vertebrae, ribs and pelvis. The bones of the hands and feet were apparently the only ones spared.

The heart developed an auricular fibrillation. This, with a mucous colitis, hastened death, which occurred, Oct. 10, 1923, at 7:15 a. m.; seven days less than one year after admission.

Fig. 7 (Case 1).—Tumors near the knee.

The clinical diagnosis was multiple myeloma; the anatomic diagnosis, multiple lymphocytic myeloma; myeloma focal tumor compression atrophy of the cerebrum; focal fibrous pachymeningitis and leptomeningitis; pathologic fractures of the femora, ribs, skull and humeri; hyperemia of the brain; edema of the leptomeninges; cellulitis of the scalp; anemic infarct of the myocardium; external bruises and abrasions; surgical scar of the left hip; hyperplasia of the

spleen; marked emaciation; generalized anemia; lessened yellow material of the suprarenal cortices; hypostatic hyperemia and edema of the lungs; cloudy swelling of the myocardium and kidneys; passive hyperemia of the liver and kidneys; slight fatty changes of the liver; fat-replaced thymus; crusted soles.

Necropsy (Dr. W. G. Hibbs).—The body was that of an emaciated boy, measuring 132.5 cm. long, with irregularly cut scalp hair. The pupils were equal. The abdomen was tense, so that the navel was raised a little above the front of the sternum. The skin, generally was dry. The foreskin was long. The testicles were in the scrotum. The soles were dry and crusted; the toe nails irregularly cut. There was a marked deformity of the right thigh so that the front of the right knee normally touched the inside of the left as it lay in the usual

Fig. 8 (Case 1).—Pathologic fractures of humeri before death.

posture, the deformity being evidently due to disease of the right hip region. The shoulders were each markedly prominent, the swelling being at the head of each humerus. The ribs were prominent generally, especially at the costochondral junctions, most marked on the right side at the fourth, fifth, sixth, seventh, eight, ninth and tenth ribs. The deformity here was that of an old fracture with repair. There was a purple bruise of the right foot laterally just below the outer condyle, and a pressure abrasion opposite the prominence of the last thoracic vertebrae. There was a little black hair on the arms. The inguinal lymph nodes were barely palpable. There was a scar of the left trochanter at the site of biopsy.

There was no recent injury of the deep scalp tissues, but the scalp was of necessity cut away from the bone because of dense fibrous adhesions generally,

and could not be torn away in the usual way. In the scalp, there were multiple petechial hemorrhages at the top of the head at about the midline, occupying a space 2 cm. in diameter. In the prominence of the occiput at the inion, there was a depressed fracture made after death. The bone here was only a delicate shell at the site of a tumor growth of the bone. The inside of the calvarium, which was removed in the usual manner, was almost three-fourths eroded away, diffusely "moth-eaten" in various size depressions from 2 to 10 mm. in diameter. The margins of the depressions were sharp, the holes punched out. Four in this vault extended through the calvarium to the dura, which was generally somewhat adherent to the calvarium and diffusely stippled with raised, gray to light brown tumor masses opposite the holes in the skull. The larger masses of the dura had a metallic luster.

Fig. 9 (Case 1).—Appearance of pelvis and hips at time of death.

In three places in the top of the brain, the visceral and parietal layers of the arachnoid were adherent by fibrous tissue, because of localized inflammatory reaction opposite the sites of erosion, through the dura of soft tumor masses of the calvarium. At a solitary place in the left cerebral hemisphere, at the center on top, 1.5 cm. to the left of the midline, there was a gelatine-like gray to red, irregularly outlined tumor mass, 11 mm. in diameter, which was eroded through the dura and visceral leptomeninges, compressing the brain at this point, with secondary atrophy of a cerebral convolution, 10 mm. deep. The convolutions of the brain on top were well rounded and the sulci were deep, because of fluid beneath the arachnoid. The brain was moderately hyperemic. Edema of the leptomeninges was marked. The left temporal lobe was discolored outside to a yellow-brown. There was no change of the right middle ear cavity, the frontal sinus, the ethmoid cell region or the sphenoid cell region.

The subcutaneous fat of the midline of the trunk in front was 2 mm. at its maximum thickness. It was coarsely lobulated and lemon yellow. The peritoneum was everywhere shiny and smooth. The lower margin of the liver was at the costal arch. The upper margin of the diaphragm on the right side was opposite the fifth rib, the fifth interspace on the left side. The spleen was normally free and weighed 90 gm. The surfaces made by section were moist,

Fig. 10 (Case 1).—Pathologic fractures of lower end of femora and upper ends of leg bones.

firm, dark red to purple and shiny. The malphigian corpuscles were distinct. There was no change of the loose tissues close to the front of the abdominal aorta. The urinary bladder was contracted tightly, and its lining was unchanged. The appendix and gallbladder were unchanged. The mesenteric lymph nodes were normal size, from 5 to 15 mm. in greatest diameters. When

cut across, these nodes were smooth, firm, moist and uniformily gray to pink. The left renal vein lay normally in front of the aorta.

Each lung filled its chest cavity normally. The pleura of each was shiny and smooth. Behind, each lung was a darker pink and slightly boggy. When sectioned, a moderate amount of frothy fluid oozed out. Nowhere was the lung solid, and nowhere in either lung were there any tumor masses.

The pericardial fluid was clear, straw-colored, and measured 12.5 c.c. The apex of the heart consisted of left ventricle. The coronary arteries were normally tortuous and thin walled. The left ventricle was in firm rigor mortis.

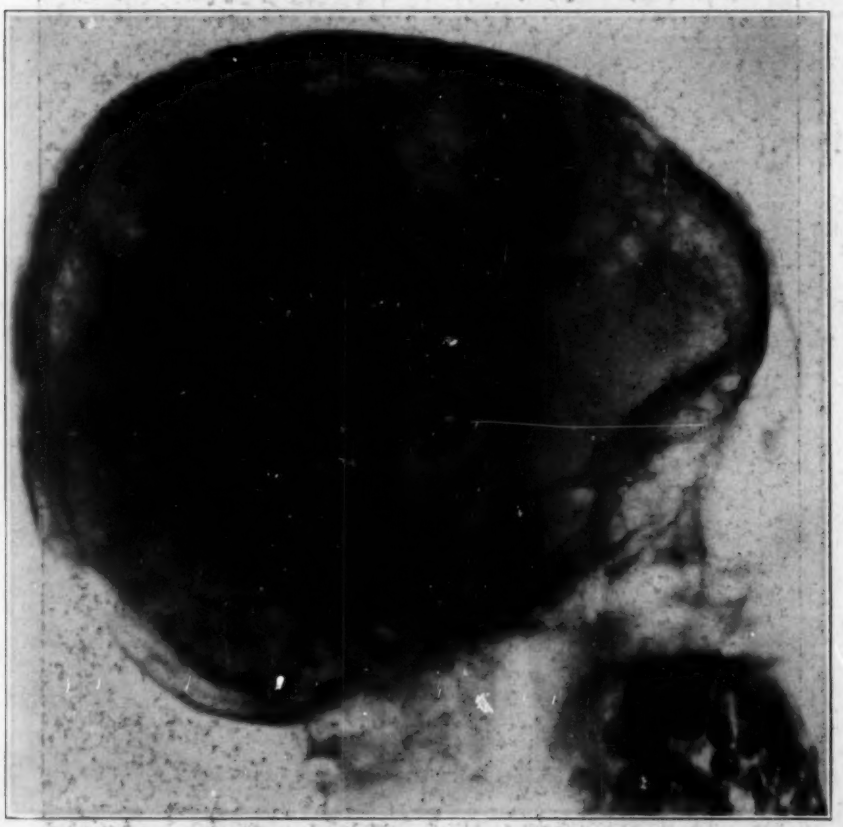

Fig. 11 (Case 1).—Appearance of skull just before death.

There was a loose goose-fat clot in the right chambers of the heart which extended out into the pulmonary artery and its branches. In running water, this clot was horse-tail shape. The coverings of the heart valves and lining of the heart were unchanged. As the interventricular septum of the heart was sectioned from front to back at the middle, a rather sharply defined area was cut into which measured 6 by 4 by 8 mm. in greatest dimensions. This area was gray to light brown, in sharp contrast to the adjacent pink to light red myocardium. It was less firm than the adjacent myocardium. It was, grossly, not the site of a tumor growth but that of an anemic infarct.

The thymus was almost entirely replaced with fat. The great veins of the neck had smooth linings and contained only loosely clotted blood. The lining of each common carotid artery was pale brown and smooth. The thyroid gland was unchanged. The tonsils were unchanged, the lymphoid tissue of the base of the tongue was normally irregular, with pinhead sized nodules which roughened the surface. The lining of the trachea was gray pink and covered with a little

Fig. 12 (Case 1).—Calvarium, from outside.

frothy mucus. The lining of the esophagus was unchanged, as was that of the larynx. The nasopharynx was dark pink and generally smooth. The deep cervical lymph nodes were from 6 to 12 mm. in their greatest diameters. When cut across, they were firm and smooth, gray to pink.

The inferior vena cava had a smooth lining and contained loosely clotted blood. The lining of the entire aorta was smooth and pale yellow-brown. The

lumen of the aorta was uniform. The thoracic duct contained thick pale gray fluid lymph.

The right suprarenal cortex was irregularly stippled with yellow pinpoint sized areas. Its medulla was smooth, shiny and gray. The left suprarenal was like the right in all essentials.

The two kidneys weighed 175 gm. The capsule of each stripped easily, leaving a smooth surface. The surfaces made by sectioning had a smooth gray

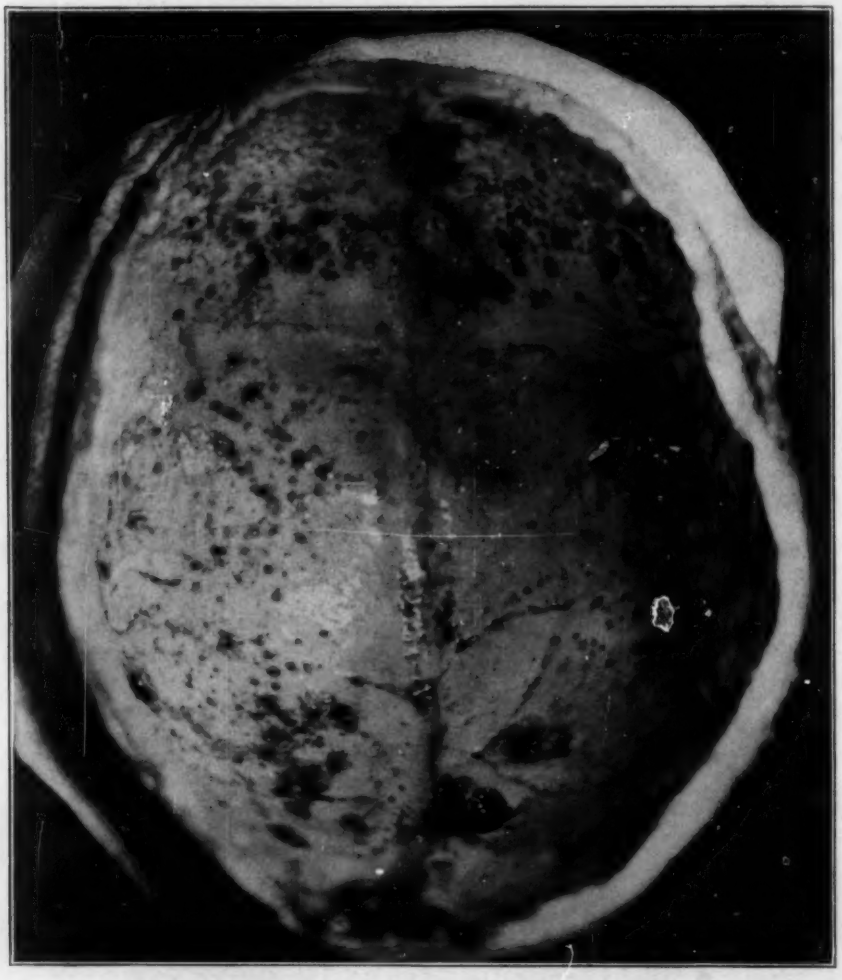

Fig. 13 (Case 1).—Calvarium as seen from inside.

to light brown cortex, uniformly 4 mm. wide, and were in distinct contrast to the dark pink to brown medullae. The cortical striations were distinct, and the parenchyma bulged where sectioned. Nowhere were there any metastatic tumor masses. The lining of each kidney pelvis and ureter was unchanged.

The liver weighed 1,422 gm. The surface was smooth. The outside was generally dark brown and moderately stippled with fat. The surfaces made

by sectioning were blood-stained, smooth and glistening, dark yellow to brown. The lobular markings were a little indistinct, the central veins being pale pink, pinhead sized. On these surfaces, the peripheries of the lobules, diffusely of the entire liver, contained fat, but only approximately one twelfth of the liver was fat.

After the trunk had been completely eviscerated, the skeleton as seen from the inside of the trunk was diffusely mottled, with raised, dark-gray to dark-red tumors. The ribs were each involved, some of them in several places. The location was not uniform, but in most was adjacent to the spine. This was also true of the sternum, the front of the vertebral column and the pelvis. These tumors were small nodules, 1 to 2.5 cm. in diameter and multiple. Where cut into, the tumors were very soft, opaque and dark red. In places, the bone at the tumor growths was absorbed; while at the ribs especially there were

Fig. 14 (Case 2).—Bilateral exophthalmos.

five areas of bony overgrowth at the sites of healed, pathologic fractures of the bones, at the tumor masses.

All of the loose tissues were reflected in order to expose practically all of the skeleton so far as possible and still retain the contour of the face, the scapulae, clavicles, cervical spine, lumbar spine, humeri, radii, ulnae, femori, tibiae and fibulae being exposed.

During the removal of the femori from the hip sockets, the head of each was accidentally fractured at the anatomic neck although extreme care was used in its removal. These fractures were caused by a huge new growth here, which was spongelike but firm, dark red to brown. The greatest diameter was 12.5 cm. (middle). When the long bones were sawed longitudinally, the marrow of each was scanty, and was replaced with gelatine-like masses in islands generally 5 to 18 mm. in diameter. These tumor masses were quite sharply defined,

glistening, friable and gray to dark pink. At least one third of the marrow of all of the long bones was so replaced, and each bone was about equally involved. These new growths were essentially similar in all of the skeleton, as was determined by longitudinal section of the long bones and transvere sections of such bones as the scapulae and sternum. In the heads of the femori and of the humeri, the huge tumor overgrowth as above described, was spongelike and dark red.

Fig. 15 (Case 2).—Large tumors of ilium and femur.

Nowhere in any viscera of this body was there found a tumor mass, either similar or dissimilar to those found in the skeleton.

After hardening in formaldehyd, the tumor masses of every representative bone was prepared for microscopic study by the paraffin method and stained with hematoxylin and eosin.

In every specimen, the histology was similar. The predominating cells of the tumors had all of the features of lymphocytes, although there were present

a few small, scattered plasma cells. Occasional mitotic figures could be visualized. These cells had a diffuse arrangement in groups of from 400 to 600 cells, interspersed with marrow cells, separated generously by pink, fibrin-like stroma. In places, especially at the ends of the femur, the cells were densely compact, and the bulk of the tissue was delicate stroma. Nowhere was there any new bone formation.

Microscopic examination of the brain, spinal cord and each of the viscerae of the trunk confirm the changes observed grossly.

CASE 2.—*History.*—L. H., girl, white, 3½ years of age, was first seen by me in the outpatient service of the orthopedic department of the Children's Memorial

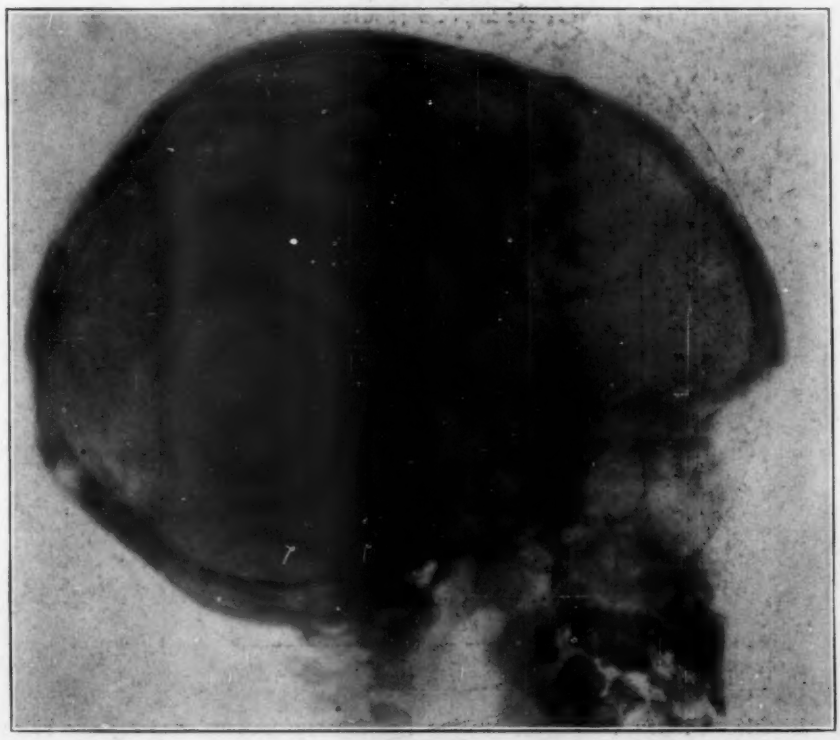

Fig. 16 (Case 2).—Multiple perforations of the skull.

Hospital, March 15, 1920, when the following history was given. The parent stated that the child was weak in the right hip and that this condition had been present for the past year, or since she was 2½ years of age. She was able to walk but complained of pain in the right thigh. Otherwise, she had been perfectly well and had had no acute illness previously.

On examination the temperature was 99 F. The patient walked with a marked limp of the right limb, which was almost 2 inches (5 cm.) shorter than the left, and there was a quarter of an inch atrophy of the right thigh and calf as compared to the left. There was questionable muscle spasm about the right hip.

Roentgen-ray examination of both hips and the pelvis revealed the condition shown in Figure 15.

When she was next seen, it was learned that she had been admitted to Presbyterian Hospital, Dec. 21, 1920, on the service of Dr. D. B. Phemister, where the following history was obtained: There was pain in the leg and hip (right), also in the right arm, and exophthalmos. The patient was a bed wetter, was irritable, and had swollen glands. About nineteen months before, at age of 2½ years, she began to complain of pain and tenderness in the right hip, especially in the inguinal region. This seemed to grow worse as time went on and she began to limp. She also cried out with pain when she sat

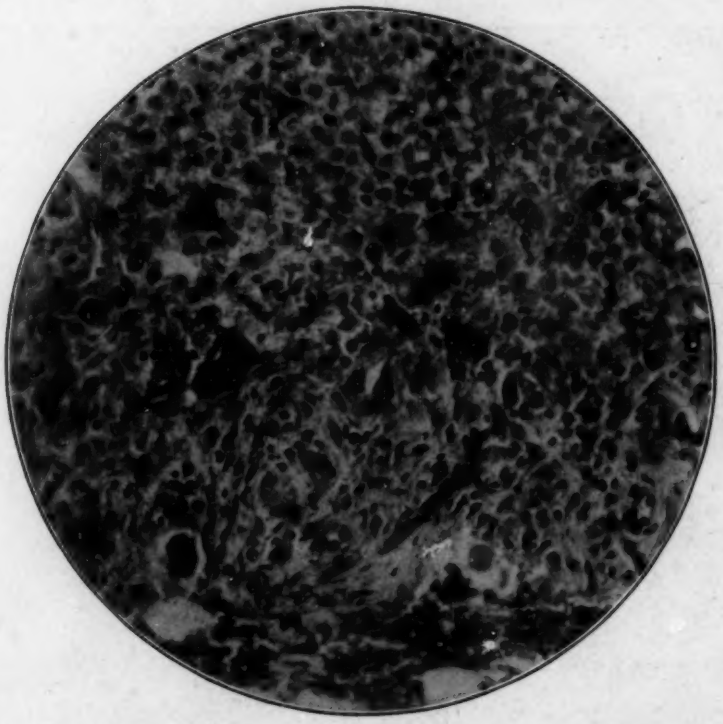

Fig. 17.—Photomicrograph, showing (*a*) myelogenous cells along one side; (*b*) fibrous layer in middle, containing foreign body giant cells, and (*c*) necrotic border.

on the right hip. She was seen at Children's Memorial Hospital six months previously, where she was told that the leg was 2 inches (5 cm.) short from actual and false shortening due to the flexion adduction deformity. Bulging of eyes had been present for sixteen months and was becoming worse (Fig 14). She was sent by Dr. E. V. L. Brown, whom they consulted about the eyes, to Dr. Phemister.

Pain in the hip and leg had been increasing, and there was pain and tenderness in the right axilla and the upper right humerus. She walked with a wabbling gait. She was irritable and cried, holding her breath until she was blue in the face. She slept very little and often started up in her sleep crying.

The birth had been normal, at full term. The child was breast fed for six months and then put on "Eagle Brand' milk for three months and later on certified milk. She had a severe attack of measles at nine months of age. About this time, she began to have a severe eczema about the head, which spread later to the body. This eczema persisted to the present time, although it had practically subsided. The development of the child was normal up to eighteen months before. She ate little wholesome food but was fond of candy and pastries. The bowels were regular. The patient slept lightly. She had been having a slight elevation of temperature for some time.

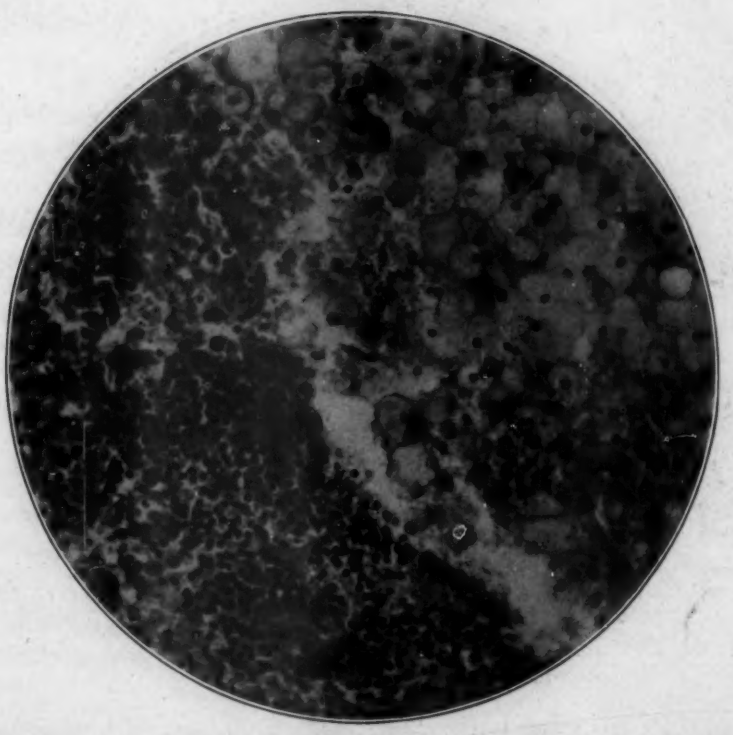

Fig. 18.—Large vacuolated and granular cells in an area of degeneration; many lymphocytes in bordering tissue (*a*).

She was the only living child. There had been one other pregnancy, with a miscarriage at five months. One brother and one sister of the father were living and well. One brother and one sister of mother were living and well. Two sisters were born dead.

Physical Examination.—The patient had marked exophthalmos, and looked rather undernourished.

The hair was cut short and the scalp badly infected with eczematous lesions. There was marked bulging of the eyes, and the sclera was prominent. The pupils were equal and reacted to light and in accommodation. Rotation was normal. The sight was apparently good. Lacrimation was pronounced.

There were no marked depressions of the skull, or elevations except for a slight elevation over the left eye. In the neck there were pea and marble sized glands, palpable in the cervical region.

The chest expansion was normal, and the lungs were resonant and clear throughout.

The right substernal border of the heart was in the left third interspace. The tones were regular and of good quality. The apex beat was not palpable.

The liver and spleen were barely palpable. The kidneys were not palpable. No abnormal masses could be felt.

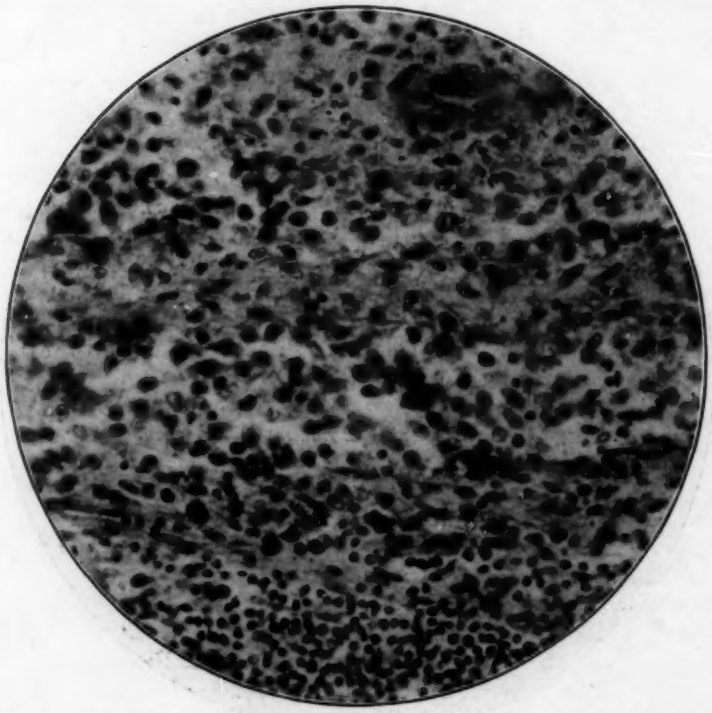

Fig. 19.—Fibrous and myelogenous cells, with an area of lymphocytes on one side (*a*).

There was tenderness over the right inguinal region and posterior to the upper end of the right femur; also over the pelvis and in the right axillary region. The hip bones on the right side were less prominent than normal. The distal end of left humerus had a lemon sized spindle shaped tumor, which was not tender and was very firm. The patient walked with a "wabbling gait." There was epitrochlear and inguinal glandular enlargement from pea to marble size. The patient was keenly intelligent.

The weight was 31 pounds (14 kg.)

Laboratory Findings.—The blood count was: Red cells, 3,500,000; white cells, 7,000; hemoglobin, 44 per cent. The blood pressure, systolic, was 98, diastolic, 60. The Wassermann reaction was negative. The urine was negative. Bence-Jones protein was not found.

Roentgen-Ray Findings.—Examination of the pelvis and hips revealed the multiple tumors of the pelvic bones and upper end of the femur, as shown in Figure 15. The same type of tumor was found in the lower end of the left humerus and in the skull (Fig. 16).

Dr. Phemister's description of his operation, Dec. 23, 1920, and the microscopic interpretation of the surgical material excised under ether anesthetic as given by Dr. Herb, were as follows:

The lower end of the shaft of the left humerus was exposed and a slight spindle shaped enlargement was found. A window one-third inch wide and 1 inch long was excised from the markedly thinned cortex. The interior of the bone in the region showing central destruction in the roentgen ray was filled

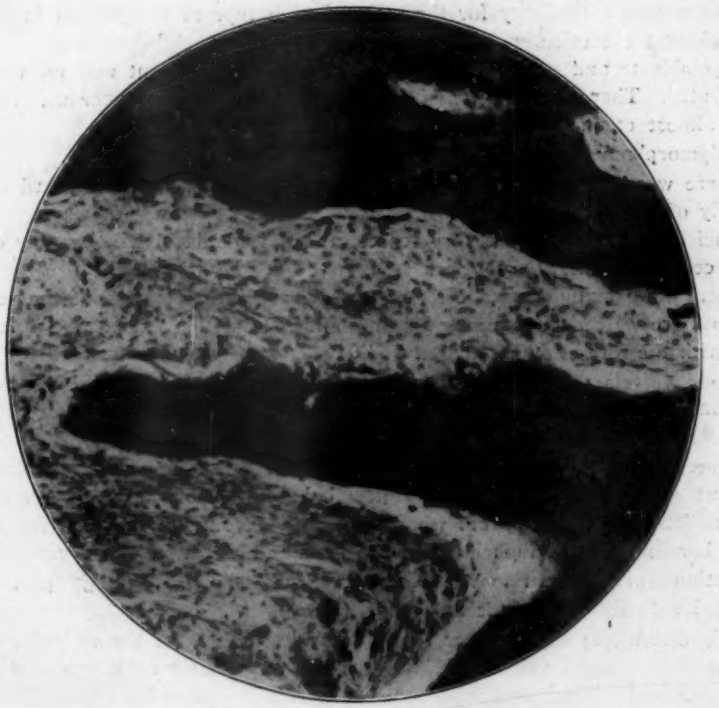

Fig. 20.—Rarefied bony wall with fibrous marrow.

with a soft tissue, which was reddish in its peripheral portions, but light gray or yellowish and necrotic in its inner portion, and had broken down and formed a cyst filled with serohemorrhagic fluid, which comprised about one-third of the contents of the area. None of the tissue was greenish.

Microscopic examination of the soft tissue removed showed it to be composed of a mixture of tissue apparently coming from the reticulum and of myelogenic cells, both of which varied greatly in amount and cell type in different portions of the tissue.

The tissue was richly cellular in its peripheral portion and degenerated toward the center, where it borders on the cavity filled with fluid. The reticular element was more abundant about the periphery, where it consisted of spherical

reticular cells and spindle shaped fibroblasts. Some of the former showed typical karyokinetic figures. There were also many giant cells in this region which were of the foreign body type. In a few places, there was maturation in the fibrous tissue to the point where intercellular substance was considerable and fibrillae had appeared. In the areas away from the periphery and apparently undergoing degeneration, there were numerous large granular vacuolated cells, most of which were mononuclear but many are polynuclear. These were xanthoma cells. Their protoplasm was extremely foamy as if infiltrated with minute fatlike globules. Because of the method of fixation, no stain for lipoid could be made, but Professor Maximow, who examined the slide, expressed the opinion that the appearance was due to the presence of cholesterol esters.

Much of the tumor was composed of blood cells or blood-forming cells, and there was a tendency for the cells of each type to be grouped in islands throughout the section.

Myeloblasts and myelocytes were perhaps most abundant and most evenly distributed. There were regions in which eosinophils were numerous, and they were almost exclusively of the polymorphonuclear type.

Polymorphonuclear neutrophils were few in number.

There were irregularly distributed large and small islands composed almost entirely of small lymphocytes.

Nucleated red cells were very scarce, and it is doubtful whether any of the giant cells were megakaryocytes.

There were many plasma cells scattered irregularly throughout the section, but nowhere were they concentrated in islands. Some had undergone degeneration, with the formation of Russell bodies.

Blood vessels were fairly numerous except in the degenerated portions of the tumor. There was a good deal of old blood extravasated in the degenerated areas.

A section of the bony wall showed marked rarefaction in the remaining portions of old cortex and spongy new bone formation in the subperiosteal region. The cancellous spaces were filled with fibrous marrow and the tumor tissue bordered on the inner wall where lacunar absorption was occurring.

Sections of tumor removed from the skull showed findings practically identical with those from the humerus.

It is difficult to say whether the primary lesion was of the reticular or of the blood forming element of the tumor, but the reticular cells appeared to be more uniformly distributed and more numerous. They also showed definite cell division. For these reasons, Professor Maximow thought the primary tumor was of the reticular cells, but it might have been a mixed cell lesion. Certainly the blood and blood-forming cells were present to an unusual degree to have arrived there by infiltration.

It would be correct perhaps to classify this tumor with the general group of myelomas, and to assume that the disturbance was of the undifferentiated cell which gives rise to both the reticulum and the hemopoietic tissue of the bone marrow.

It was difficult to say whether many of the more primitive cells belonged to the reticular group or whether they were "Stamm Zellen" of the blood-forming group. Since the reticular cells showed such marked tendency to transformation into xanthoma cells, an appropriate name for this tumor would appear to be xanthomyeloma.

COMMENT

Multiple myelomas occur in children as well as in adults. In backache and bone pains of obscure origin, multiple myeloma should be suspected.

Absence of Bence-Jones protein does not eliminate myeloma from the diagnosis, and its presence is not pathognomonic.

The characteristic proteinuria is found with greater frequency in the reports of patients of greater age.

The lesions in children are larger than those in adults, while in the latter the lesions are more generally distributed.

Skull lesions may perforate the outer table; if the inner table is eroded there may be an increase of intracranial pressure simulating tumor of the brain; if the portion over the motor cortex is involved there may be mechanical irritation with stimulation of tuberculous meningitis as in the foregoing cases.

Roentgenograms should be taken of all skulls in cases simulating tuberculous meningitis when the organisms are not found in the cerebrospinal fluid.

Bilateral exophthalmos is present in cases involving the skull. Patients with multiple bone tumors, especially with vertebral lesions, can be made very comfortable if placed in a posterior molded plaster shell.

7 West Madison Street.

XANTHOMAS

INTRODUCTION

JOSEPH COLT BLOODGOOD, M.D.

BALTIMORE

When Dr. Lewis asked me to write an introduction to or discussion of the two papers following, I was somewhat at a loss what to say. Dr. Garrett studied the tumors of the xanthoma group with all the angiomas and other benign connective-tissue tumors which had accumulated in my laboratory for the past thirty years, and his presentation is so thorough and so clear that he left very little to be said on the subject of the xanthoma and tumors which resemble it in the color effect.

Dr. David T. Smith, when he came to the laboratory as a third-year student, had already begun his investigation on pigment in tissues and tumors, and especially on the character of the melanin pigment in the well-known group of tumors, best designated as benign and malignant pigmented moles. Dr. Smith has continued his work on melanin and blood pigment in tumors.

For these reasons, I held the two articles until I could restudy the entire group of sarcomas of the soft parts from derma to bone, with the hope that something of practical value to surgeons and pathologists could be evolved from this great mass of material.

Although the studies are not yet completed, we have learned enough to draw attention to some fundamental truths in the methods of diagnosis and of attack of subepidermal and subcutaneous tumors.

Subepidermal Tumors.—These tumors can be seen and felt in the skin, and in their onset have a thin epidermal covering. This differentiates them at once from primary tumors of the epidermis which appear as warts, areas of keratosis, scaly areas or superficial ulcers with scabs.

The subepidermal tumor may be epithelial in origin as well as arising from connective tissue. The most common subepidermal tumor arises from displaced basal epidermal cells, and when it takes on growth, it ultimately produces the basal-cell cancer or rodent ulcer. Tumors of the spinal-cell type occur as those of the basal-cell type, but much less frequently. The subepidermal cyst or dermoid is more frequently of spinal-cell origin than of basal-cell. Solid and cystic tumors (adenoma) of the sweat and sebaceous glands are rare, but they resemble the common subepidermal nodule in appearance and on palpation. Spinal-cell epithelioma may arise from the epidermal lining of the hair follicle, and it is difficult, in fact in many instances impossible, to distinguish this type of cancer from the hair-follicle infection. Both are characterized by scaly areas, keratosis or scab formation in an hairy area, with definite induration of the derma.

Tumors of connective-tissue origin may arise in the subepidermal tissue. The most common are the pigmented moles. This tumor may appear as a pigmented area in an otherwise apparently unchanged epidermis; the pigmented area may be a smooth, domelike elevation, or pigmented mole; or an elevated warty growth, or pigmented wart. The smooth moles may be multiple and give the appearance of fibroma molluscum. Now and then, in these tumors, the pigment is so slight that the mole or wart has no color to indicate the nature of the visible lesion.

Perhaps the next most common subepidermal tumor is the congenital nevus. This, like the pigmented tumor, may be confined to the epidermis only and appear as a red, smooth area the color of which disappears under pressure, or an elevated area of the type of a mole or wart. The characteristic feature of the angioma is that its color disappears under pressure; in the pigmented tumor, it does not. Most angiomas are also compressible, at least as long as the blood in the blood spaces is part of the venous system. These subepidermal angiomas, like the pigmented moles, are of congenital origin, but their great growth may not take place until later in life. If the angioma grows, it usually does so before the age of 20, and it is usually benign; while if the mole grows, it usually does so after 40, and the local growth, with rare exceptions, is malignant and metastasizes almost at once.

The subepidermal hemangioma may be associated with a subcutaneous type which can be felt on palpation. I have never observed this subcutaneous tumor in the pigmented mole.

Any type of connective-tissue tumor may appear as a subepidermal nodule—the lipoma, the fibroma, the fibroneuroma, the xanthoma, the giant-cell tumor. Perhaps the most common is the fibroneuroma of nerve sheaths, which is often multiple.

The Cure of Subepidermal Tumors.—With the exception of the malignant pigmented mole, no subepidermal tumor should be responsible for the death of any member of the human race. These tumors are always benign at the onset, and remain so for many years. It is only when ignorance allows the tumor to grow, ulcerate and metastasize that the patient dies of malignant disease.

Every individual, even children, are aware of these subepidermal nodules, as they are of warts; any change in the epidermis, and unhealed wounds. All the public need to know is that these apparently innocent skin defects may become cancer, and they should seek the advice of a member of the medical profession who knows the proper treatment, either removal or leaving them alone until they show growth.

What the Medical Profession Should Know About Epidermal and Subepidermal Tumors.—These tumors may be divided into three groups. In one, the nodule that we can see and feel belongs to a type in which the tendency to malignancy is sufficiently great to justify its complete removal the moment it comes under the eye and finger of the physician who knows. The most common example in this group is the elevated pigmented mole, or any definite epidermal or subepidermal tumor in a region exposed to frequent trauma or irritation. In the second group, as those who have studied the question know, the visible and palpable epidermal or subepidermal nodule either runs little more risk of becoming malignant than the normal skin, or, if it has any tendency towards malignancy, will give ample warning by local enlargement. Removal or any form of treatment in tumors of this group is not necessary.

This is a fundamental truth for both the profession and the public because there is scarcely a human being born that has not one or more subepidermal nodules or minute skin lesions, which may be visible at first or may appear later in life. There is scarcely a human being who does not acquire, from injury or infection, some visible or palpable skin defect.

In the third group, even those with the greatest experience can not recognize whether the nodule belongs to the first or to the second group. The best rule, when in doubt, is to excise the nodule completely.

The Method of Attack in Subepidermal Tumors of Nodules.—The rule here is identical with that for epidermal lesions. Having decided that the best treatment is removal, the palpable area should be given a good margin of skin and subcutaneous fat, in the larger growths also of the fascia beneath.

The amount of margin of uninfiltrated tissue in a primary subepidermal nodule with no evidence of ulceration is practically identical for all possible pathologic types.

In a review the records of hundreds of epidermal and subepidermal tumors that have been received in the laboratory from all sources, what is evidenced as the most common error, even among the surgeons in our own groups? The apparently innocent nodule is not given sufficient margin, and in some instances the tumor has been cut into and incompletely removed.

The removal of epidermal and dermal tumors is looked on as minor surgery. It is usually done in the dispensary or the private office. Unfortunately, the records show that frequently these minor operations are performed by men who do know major surgery or by students and young surgeons who are more interested in the operation than in the pathology, and who are apparently ignorant or uninstructed on the danger of the incomplete removal of these apparently innocent tumors.

I feel confident that the apparent popularity, before the days of roentgen rays and radium, of the cancer pastes and the electric needle for skin tumors of this type, was due to bad surgery in the early benign stage, and late surgery, even when good, in the hopeless malignant stage. The same is apparently true with regard to roentgen-ray and radium treatment. Our evidence shows that no method of attack can compete with the proper removal of epidermal and subepidermal tumors with the knife or cautery; but anything can compete with improper removal.

I wish to emphasize this point. The gross and microscopic pathology is *post hoc*. The entire cure depends on the complete excision.

How Does Pathologic Knowledge Help?—If the surgeon studies the section of the skin nodule he has removed, or keeps himself posted on its microscopic pathology and follows his cases, he, as a rule, will learn to recognize the pathologic type before operation. But this is not of any particular help when the epidermal or subepidermal nodule is small and not a recurrent tumor. There is always the risk of giving it insufficient margin. Therefore, when the nodule is in a situation where more margin might mutilate, such as near the alae of the nose or the eyelid, or on the nose near the inner canthus of the eye, the cautery should be used instead of the knife.

Recurrent Epidermal and Subepidermal Tumors.—My studies clearly show that when the tumor is a recurrent one after any form of treatment the margin of tissue excised should be at least twice as great and the cautery should be employed. Apparently recurrence is associated with wide-spread cell transplantation, and the palpable visible nodule is by no means the only area of tumor growth. Irradiation in some cases should precede operation.

If one places tumors of the same pathologic group and of the same size and of an identical location in two columns according to the history, primary and of recurrence, and has both subjected to the same type of efficient surgery, the results inthe primary group are, with the rarest exception, 100 per cent. cures; while in the recurrent group, there are always about 33 per cent. of failures, increasing with the malignancy of the growth and its location.

These studies, which have been going on in the laboratory for twenty years and are made possible by the continuous follow-up system and the careful preservation of original records, tissues and sections, show how fundamental this knowledge of the method of attack of such a simple thing as a subepidermal nodule is.

There is every evidence that cancer of the skin is a preventable and curable disease. Prevention and cure depend on two things—the education of the public and the education of the medical profession as to the proper surgical procedure in those cases in which it is indicated.

Pigment in Epidermal and Subepidermal Tumors.—The majority of pigmented epidermal tumors are due to melanin. Now and then a warty growth resembles the pigmented tumor, yet the section shows that it is a wart and not a mole, and the pigment is due to dirt. It is known in the laboratory as a "dirty" wart. The other cause of pigment in any epidermal or subepidermal tumor is blood, which may be due to hemorrhage in any tumor, but is more frequently seen in the angioma and most frequently in that form of angioma known as the xanthoma.

The differentiation of the three types of pigment—melanin, blood and dirt—is for the purpose of prognosis rather than treatment, because, in the vast majority of cases, the tumor has been removed. If, as in the cases described by Dr. Smith, the pigment is melanin, we know that we are dealing with a tumor of the pigmented mole group; and if the cells are of the malignant type, we know it is a malignant pigmented mole, and the chances of a permanent cure are less than 1 per cent.

Subcutaneous Nodules.—As stated before, the benign or pigmented mole never occurs as a distinctly subcutaneous nodule. The majority of these tumors are either of the benign connective-tissue group or sarcoma. There are a few of epithelial origin: the dermoid cyst—and we may encounter here a new type of tumor not observed in the true skin—myositis of all types; the lymph cyst and the blood cyst; the chronic abscess, the organized hematoma, and the most interesting of all, on the fingers near the tendon sheaths, the granulation-tissue tumor; and then again we must remember the bursa as a possible explanation of the subepidermal tumor.

Recurrences in Subcutaneous Sarcoma.—Now that we have restudied the large group of sarcomas of the skin and soft parts, we find that the conclusions reached in 1910 still hold true. Recurrences in sarcoma of the skin and soft parts differ from those of sarcoma of bone. In sarcoma of bone, death occurs from metastasis to the lung, because the usual operation is amputation for involvement of bone. In sarcoma of the soft parts, the majority of those who die first have a local recurrence. This is due either to late intervention when the disease has infiltrated too far or to improper early intervention.

The Danger of Enucleation and of Shelling Out Subcutaneous Tumors.—The fundamental facts which stand out in our study of the causes of failure to cure in benign and malignant lesions of the skin were late intervention due to the ignorance of the individual, and bad surgery—incomplete removal—in the early stage. The same evidence is found when we study the recurrences after operation for subcutaneous benign and malignant tumors. Late intervention and, in those fortunate people whom education has brought to the medical profession immediately after the palpation of the nodule, enucleation or shelling out of the tumor have been the only factors to explain the local recurrence. These indi-

viduals, therefore, fortunate in their correct information, were unfortunate in the selection of their surgeon.

There may be some criticism of this statement of the common employment of enucleation or shelling out of subcutaneous nodules, but the evidence of the accumulated experience of the surgical pathologic laboratory of the Johns Hopkins Hospital cannot be an exception. These tumors not only come from our own clinic, but also have been sent from other clinics throughout the country.

The Fundamental Principles in the Diagnosis and Treatment of Subcutaneous Nodules and Tumors.—These are practically identical with what has already been discussed in connection with the subepidermal nodule. The public should be told that when a lump is felt beneath the skin, the advice of a physician should immediately be sought, in order to determine whether the lump should be removed. It is our business to learn through palpation, situation and history which lumps need not be disturbed. Operation having been decided on, the point to remember is that the apparently innocent and encapsulated nodule may be a sarcoma, and, therefore, in every case in which it is possible, the nodule should be removed, with sufficient margin of uninvolved tissue so that if the tumor proves to be a sarcoma the local removal will have been as complete as possible.

When Complete Local Excision Is Possible Without Mutilation.—This complete operation should always be performed for any type of epidermal, subepidermal or subcutaneous tumor, if it can be done without mutilation. It is impossible, especially in the early stages, to distinguish the benign from the malignant growth; and in these early stages, there is the best opportunity to cure the malignant by proper local intervention. This complete operation is never harmful for the benign growth, in fact, incomplete operations for benign growths are as liable to be followed by recurrence as are those for malignant tumors. The result, however, is less serious. In this group, therefore, the pathologic process develops postoperatively, and is of prognostic value.

It is important again to emphasize here that, in the study of sarcoma of the skin and soft parts, the largest percentage of recurrences have been on small dermal and subcutaneous tumors in which the operator had looked on the lesion as innocent and limited the extent of the local excision, or enucleated or shelled the tumor out.

For example: A patient enters the dispensary with a small nodule near the internal malleolus. This patient has come within a few days after the nodule appeared, having read of the importance of such action. The operator considers the ganglion only, explores, enucleates and, as the tumor would not be readily enucleated, removes it with the knife, cutting near the apparent capsule. He then closes the wound. To his chagrin, the tumor is not a ganglion, but a solid tumor. It is rushed to the laboratory and found to be a sarcoma, and the surgeon is in a dilemma. In spite of postoperative roentgen-ray treatment, this tumor recurs. The local removal now may mean amputation, but the chances are that metastasis has already taken place. This tumor could have been completely removed at the first operation with the cautery, without mutilation.

My records of tumors sent to the laboratory for diagnosis demonstrate that examples of this kind are on the increase. When the tumor of the skin or soft parts is large and the operation for its removal must be extensive, the patient reaches the most experienced surgeon, as a rule at a period when this experienced surgery is of little avail. The smaller and apparently innocent and

probably largely curable sarcomas come under the care of the younger and less experienced operators. Those who know seem to find it impossible to get this fundamental message to the younger group of surgeons.

When Complete Local Excision Is Not Possible Without Mutilation.—One must not at once conclude that these are always malignant tumors. If this were true, one should proceed with the operation of complete local removal no matter what the mutilation, or not operate at all, and depend on roentgen ray or radium. In the majority of cases, when a malignant tumor has reached this stage, the chances of a cure by any method of treatment are relatively small.

The first thing to do is to make a diagnosis, considering the possibility of syphilis, since gumma of the extremity may assume the clinical picture of sarcoma. A roentgenogram should always be taken. The diagnostic value of the soft-part tumor shadow is far behind that of the bone tumor shadow, but ossification in a soft-part tumor not connected with the shaft of the bone practically excludes sarcoma and indicates ossifying myositis. Calcification of the soft-part tumor excludes malignancy and favors tuberculosis.

The location of the palpable mass is helpful. If a palpable tumor is on the fingers or toes malignancy is practically excluded. Sarcomas are very rare in the region of the bursae, especially the prepatellar bursa (housemaid's knee) and over the olecranon (miner's elbow).

Exploratory Incision and Frozen Section.—Ultimately, in the majority of cases, the diagnosis must rest on cutting into the tumor and deciding from the gross appearance and the frozen section the nature of the disease. It is in this group that such studies as Garrett's on the xanthoma and Smith's on pigment, are helpful.

The xanthoma is a combination of a remarkably striking color effect in a relatively solid tumor. The solid sarcoma (fibrospindle-cell), with the rarest exceptions, never has the mottled appearance of the xanthoma, while the sarcoma colored by blood pigment and the malignant pigmented mole colored by melanin are always friable, so that, in the majority of cases, the benign pigmented tumors of the xanthoma group can be recognized by their color effect and consistency. All benign tumors with the peculiar coloring of the xanthoma are not of identical histology. Hemorrhagic bursitis resembles the xanthoma, especially when there is no cavity, and now and then we have observed it when hemorrhage has taken place into a lipoma or myxoma. A fibromyxoma of the nerve sheath observed recently in the region of the malleolus and associated with varicose veins, had grown to the size of an orange and resembled in the gross the ordinary xanthoma.

It requires considerable experience to distinguish these very cellular fibrohemangiomas and xanthomas from sarcoma, in the frozen section, just as it is difficult to differentiate certain types of bursitis from sarcoma.

Foam cells: These are not always present in these tumors colored by blood tissue, but when present, from our studies up to date, exclude sarcoma.

Giant cells: These cells of the epulis or foreign-body type, when present in soft-part tumors, practically exclude sarcoma.

The evidence derived from this continuous study indicates that if the surgeon is in doubt a mutilating operation should not be performed. The chances of curing the sarcoma are too small, while the probabilities of the lesion being benign are too great.

Tendon-Sheath Tumors.—When the soft-part tumor is distinctly adherent and is related to one or more tendon sheaths, even when situated above the

fingers and toes, on the hand, foot, ankle or wrist, and the tumor has the mottled coloring of the xanthoma, sarcoma can be almost excluded, and mutilation is not essential for a permanent cure. I called attention to this twenty years ago.[1] These two cases are again reported by Garrett. One was situated above the ankle, and was of such a size that its complete removal would have led to amputation. In the other, the tumor was in the muscle of the thenar eminence of the thumb. Here also amputation only would have completely removed the tumor. Both patients refused amputation, fortunately for them. These two cases were my first introduction (about 1896 or 1897) to the blood-pigmented tumors, then classed as hemangiomatous elephantiasis or fibro-hemangioma. Since then I have found that Paget and Lebert described and recognized them as benign in 1850.

It is surprising how frequently the smaller pigmented tumors connected with the tendon-sheaths of the fingers are sent to the laboratory with the diagnosis of sarcoma or malignant pigmented tumor, with the question: Shall amputation be performed? These tumors are often just as cellular as sarcoma. The most helpful fact is their situation; next the presence of giant cells and foam cells. These tendon-sheath tumors may recur, but up to the present time there is not a single example of death from recurrence or metastasis. A number of unnecessary amputations have been performed and many more have been urged.

Tumors of Bursae.—Next to the tumors in the region of tendon-sheaths, for their interest in differential diagnosis, come the lesions of the bursae. As stated before, the situation in the region of a bursa indicates benignancy. Sarcoma of the bursae is very rare. The presence of a definite cavity, the remains of the bursal sack, is evidence against malignancy. Microscopically, the majority of the lesions of the bursae are easily differentiated from sarcoma.

At the present time, I have under observation a patient with a lesion in the position of the prepatellar bursa. The sections are diagnosed sarcoma by some pathologists, a benign inflammatory lesion by others. The tumor recurred after partial removal, but the patient is well now almost two years after roentgen-ray and radium treatment, and the question to be settled is: Is this a cure by irradiation, or the natural spontaneous cure of a benign inflammatory lesion? Personally, in this case, I felt so convinced that it was sarcoma that I advised amputation. (This advice was given before the present study was completed.)

Quite recently, I saw in Dr. Dean Lewis' clinic, with Drs. Lewis and Phemister, a tumor in the region of the prepatellar bursa. Clinically, it looked like sarcoma. The tumor was removed with the cautery, but the operation was a limited one, not going far enough to jeopardize the knee-joint. When removed, it proved to be a gumma. The wound healed, and the man has good function. In this case, one could easily have been persuaded to perform an amputation for sarcoma.

About twenty years ago, a man came under my observation with a huge, rapidly growing tumor of the buttock, the classic picture of sarcoma. There was intense sciatic pain, and the patient was begging for a hip-joint amputation. On exploration, the tumor proved to be a bursa, tense with fluid, associated with an exostosis near the neck of the femur which did not show in the roentgenogram. The condition was recognized at once at the exploratory incision.

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1. Bloodgood, J. C.: Prog. Med., December, 1903, p. 154, Figs. 16 and 17.

CONCLUSIONS

I trust that these two papers with my, I fear, too long introduction, will excite interest in the benign and malignant tumors of the soft parts, which will ultimately lead to a series of studies and publications which are now going on in regard to tumors of bone. I am inclined to think that we will find them just as important and just as large a group, and from the standpoint of a cure of sarcoma, offering a greater possibility of a cure.

The educational effort throughout the country on cancer is bringing these patients to seek advice earlier. The surgeon especially needs enlightenment in regard to recognition and treatment, and every clinic in the country has unpublished material.

TUMORS OF THE XANTHOMA TYPE*

CHARLES A. GARRETT, M.D.

BALTIMORE

As a basis of this discussion, I have reviewed all the cases classified as fibrohemangioma, fibroma of tendon sheaths, granulation tissue tumors, tumors of bursaé and tumors of joints, which have come into the surgical pathologic laboratory of the Johns Hopkins Hospital, a total of 196 cases. These tumors present certain similarities which I shall point out. In all groups, there are examples of xanthoma, and in some cases diagnosis of cancer was made.

In the literature, there has been considerable difference in classification. This type of tumor has been referred to by many names,[1] such as myeloma, xanthoma, sarcoma, endothelioma, granuloma or giant-cell tumor, or by a combination of these names. I shall attempt to point out the features of this group of benign tumors with as little reference to confusing names as possible. It should be remembered from the start that even at the present time these tumors are constantly being mistaken for malignant neoplasms by expert pathologists, although they are essentially benign.

Paget, as early as 1854, in his "Surgical Pathology," under a discussion of myeloid tumors, refers to a group of tumors similar to these cases. They were first differentiated from similar fibrous tumors, and especially from sarcoma, by Lebert, previous to that time. Paget refers to a peculiar giant cell which he thought was typical of his so-called myeloid tumors. He states that these tumors are found in many situations—the mammary glands, eyelids, conjunctiva and subcutaneous tissue, but especially in connection with bone. He describes the cut sections of these tumors as smooth, uniform, and compact, and containing a yellow fluid. There are blotches of brown and red and grayish white throughout the tumor. Lebert stated that the peculiar greenish yellow is due to a peculiar sort of fat, which he calls xanthos; a view not far removed from an opinion which is prevalent today, seventy-five years later. We do not believe that there is anything specific about this color or the pigment of these tumors, but that it is simply an indication of blood destruction. Paget's[2] microscopic description is good. He recognized and described (1) large, oval pigmented cells, (2) irregular

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*From the Surgical Pathological Laboratory, Johns Hopkins Hospital.

1. Heurtaux, M. A.: Myelome des gaines tendineuses, Arch. gén. de méd. **167**:40-50, 160-169, 1891.

2. Paget, Sir James: Surgical Pathology, 1854.

fragments of cells without a definite cell wall but with many nuclei, (3) typical giant cells and (4) spindle cells. He does not describe foam cells as such.

Recently, Broder, in writing on the subject of benign xanthic tumors of the extremities, stated that the yellow color, with the foreign body giant cells, was the most striking feature of extraperiosteal tumors of the extremities.

Targett,[3] in 1897, considered the "giant cell tumors of the integument" malignant, both clinically and histologically; and the presence of giant cells suggested to him that the tumors originated "from some bone-forming membrane."

Dor,[4] in 1898, stated that this tumor should be called myeloxanthoma. His theory is interesting: that xanthomatoid cells and giant cells are the result of totally different processes of evolution, but they are derived from identical cells; in the first case, the cells remain isolated; in the second, their nuclei blend, making a single cell with multiple nuclei.

Bellamy,[5] in 1901, stated that though a myeloid tumor in the sense that it contains an abundance of giant cells among its tissue elements, the xanthoma possesses no claim to be regarded as a member of this class; the fact that the evolution of the tumor is due to proliferation of the endothelial cells of the blood vessels stamps it is an endothelioma; a view in which we concur. He states further that in view of the large part taken by giant cells in its composition, it seems rather to merit the name of myeloid endothelioma.

Bloodgood,[6] in 1903, described three cases very similar to the group under discussion; and these cases we now believe to be of xanthoma type. At that time, he called them hemangiomatous elephantiasis. The tumor he described was of the nevi type, but with such a proliferation of the fibrous and cellular tissue that the angiomatous character of the tumor was lost. They appeared as solid, firm fibrous tumors which suggested neoplasms. Macroscopically, these cases showed the characteristics which have since been ascribed to xanthomatous tumors. Microscopically, there were many blood vessels about which there were many round and spindle cells, much pigment and a few lymphoid cells. In the fibrous part of the section, the chief features are the spindle cells and proliferating endothelial cells. These were considered benign, and subsequent history proved the diagnosis to be correct.

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3. Targett, J. H.: Giant Cell Tumors of the Integuments, Tr. Path. Soc. London **48**:230-235, 1897.

4. Dor, L.: Relations des tumeurs à myeloplaxes et des xanthomes, Cong. de chir. **12**:558-562, 1898.

5. Bellamy, H. F.: The Myeloid Tumors of the Tendon Sheaths, J. Path. & Bacteriol. **7**:465-480, 1901.

6. Bloodgood, J. C.: Tumors, Benign and Malignant, Prog. Med., December, 1903, pp. 154-158.

In 1905, Bloodgood [7] again referred to this class of tumors under the discussion of fibroma of tendon sheath and referred to this class of tumors as a whole as benign. Muller [8] also called this class of tumors benign. But Flessig,[9] in 1913, was the first to separate the benign extraperiosteal growths of the tendon sheaths from malignant neoplastic tumors. He states: "The tumors called myelomas or giant cell sarcomas, which occur in the tendon sheaths of the fingers and toes, the hands and feet, and most probably the forearm and legs below the elbow and knee, are not true tumors (malignant). The simplest designation would be granuloma of tendon sheaths."

Tourneux,[10] in 1913, collected from the literature on sarcoma of the tendon sheath ninety-three cases, of which fifty-four should be classed as xanthic tumors with giant cells.

Stewart and Flirt,[11] in 1915, found nine additional cases in the literature and reported nine new cases.

Reid,[12] in 1914, made an excellent report of a case of xanthoma, together with a review of four similar cases from the surgical pathologic laboratory of the Johns Hopkins Hospital. He describes specifically the "typical foam cells," and the giant cells and the spindle cells which have been mistaken for sarcoma. Reid also believes that these foam cells are not distinctive or pathognomonic of the xanthoma and that they are due to the absorption of cholesterin from the broken down blood. Hence, they do not stand in any etiologic relationship to the tumor. He believes, also, that the pigment, which has been discussed so much in the literature, is nothing more than destroyed blood. We quite agree in this opinion.

Beekman,[13] in 1915, reported three cases of giant cell tumors of tendon sheaths which contained typical giant cells, but they were apparently not of the xanthoma type. He discussed thoroughly the pathology of these cases.

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7. Bloodgood, J. C.: Malignant and Benign Tumors of the Extremities, Prog. Med., December, 1905, pp. 264-269.

8. Muller: Zur Kenntnis der Fingergeschwülste, Arch. f. Klin. Chir. **63**: 348, 1901.

9. Flessig, F.: Ueber die bisher Riesenzellen (Myelome) bezeichneten Granulationsgeschwülste der Sehnenscheiden, Deutsch. Ztschr. f. Chir. **122**: 239-265, 1913.

10. Tourneux, J. P.: Les sarcomes des gaines tendineuses, Rev. de chir. **47**:817-854, 1913.

11. Stewart, M. J., and Flirt, E. R.: Observations on the Myeloid Tumors of Tendon Sheaths, Brit. J. Surg. **3**:90-99, 1915-1916.

12. Landois, F., and Reid, Mont: Das pigmentiente riesenzellenhaltige Xantho-sarkom der Extremitäten, Beitr. z. klin. Chir. **95**:56-73, 1915.

13. Beekman, Fenwick: Giant Cell Tumors of Tendon Sheaths, Ann. Surg., December, 1915, pp. 739-746.

Broders,[14] in 1919, reported seventeen cases of "benign xanthic extraperiosteal tumors of the extremities containing foreign body giant cells. Of the seventeen cases, sixteen were connected either with a tendon sheath or with a tendon. This observation has been made by several writers on the subject, but it is not confirmed by our cases. The gross pathology in his cases is that which I shall describe subsequently for so-called xanthoma. Microscopically, he finds giant cells in all his cases and foam cells in 64 per cent. of his cases. He states that blood pigment is evident in almost every microscopic field. There are also fibrous areas which contain spindle cells and a few other cells of various description.

Hartman[15] recently has made an interesting report on synovial membrane tumors of the joints, in which he reviews the literature and reports a case. His case was diagnosed clinically as villous arthritis of the knee. Aspiration was performed repeatedly, but the case finally came to operation. Macroscopically, the tumor is of the xanthoma type, and Hartman describes the three types of cells which are so typically a feature of these cases: (1) round pigmented cells; (2) foam cells and (3) giant cells. Reid[12] has also referred to the possibility of the occurrence of these xanthoma-like tumors in the knee. Hartman refers to sixteen similar cases in the literature.

There has been a considerable discussion relative to the origin and nature of these so-called foam cells, which have been thought to be a typical feature of xanthoma. Smith,[16] in 1912, has given a most interesting discussion on this point and has reported four additional cases of foam cell tumors. I shall refer to some of the facts he pointed out. Much work had been done before that time on a double refractive, fatlike substance found normally in the tissues of the body; but Kawamura[17] showed that the substance was a definite compound-cholesterin ester or cholesterin fat. Normally, it is found in the suprarenal gland, less frequently in the ovary, testicle, thymus, hypophysis, thyroid, puerperal uterus and the gallbladder mucous membrane. Pathologically, it has a wide distribution in the body in almost any chronic nutritional or chronic inflammatory condition, but, according to Kawamura, it is not a feature of acute inflammation.

This substance may be contained within gland cells, endothelial cells and connective tissue cells, wandering cells with one nucleus, and plasma

14. Broders, A. C.: Benign Xanthic Extraperiosteal Tumors of the Extremities Containing Foreign Body Giant Cells, Ann. Surg. **70**:574 (Nov.) 1919.

15. Hartman, F. W.: Synovial Membrane Tumors of Joints, J. Surg. Gynec. & Obst. **34**:161-167 (Feb.) 1922.

16. Smith, Carroll: Histology and Nature of the So-Called Foam Cell Tumors, Surg. Gynec. & Obst., 1912, pp. 550, 557.

17. Kawamura, A.: Die cholesterinesternerfettens, Jena, 1911.

and glia cells. Such cells, when filled with this fat, are uniform, do not tend to degenerate and appear as epithelial-like round or elongated cells, In alcohol preparation, in which the fatty globules have been dissolved, the cytoplasm on high magnification seems to consist of small meshes of apparently equal size which give the characteristic appearance of foam. Pick [18] has shown this foamy structure of xanthoma and giant cells to be due to cholesterin fat; but Smith points out that this foam cell is in no way specific for xanthoma, but occurs whenever cholesterin fat is found totally filling the cells. As to the origin of this fat within the cells, Pick has suggested that it is due to one of three processes: (1) infiltration, or (2) physical or (3) chemical disturbance within the cells. It is the first of these processes which has to do with the "foam cells" which we will consider (Smith).

Smith suggests that, instead of using the term foam cells for all the types which contain cholesterin, we classify them into two groups: (1) infiltration structures (not true new growths), and (2) true "foam cell" new growths. The former are transitory and tend to disappear, and are associated with disturbed metabolism (diabetes or icterus); infectious areas, such as old pus tubes or appendix abscess (Pick); chronic gallbladder inflammation (Aschoff [19]); dermoid cysts (Pick) or degenerating tumors, such as sarcomas or carcinomas (Smith).

Under the latter group (Group 2, above) we are to consider xanthomas as true new growths, according to Smith. This ability of cells of new growths to become infiltrated with cholesterin fat as a consequence of disturbed metabolism without degeneration seems to belong exclusively to the connective tissue—endothelial groups of tumors. Foam cells, however, may appear in neoplasms the mother cells of which physiologically contain cholesterin fat—as in cases of tumors of the suprarenals (Kaiserling and Orgler [16]), and possibly in carcinoma of the prostate (Schlagenhaufer [20]). On the other hand, cholesterin fat may be set free by degeneration of neoplastic cells and secondarily infiltrate the stroma, giving pseudo-xanthoma (Smith).

Smith refers especially to a "xanthoma en tumeurs," or true tumors, in which all the tumor cells, or part of their base, become converted into foam cells without signs of degeneration. Several of these cases had been described in a tendon of a toe, a tendon of a finger (Kammer [21]),

18. Pick, L., and Pinkus: Weitere Untersuchungen zur Xanthomfrage, Dermat. Ztschr. **16:** No. 12.

19. Aschoff: Zur frage der Cholesterinbildung in der Gallenblase, München. med. Wchnschr. **38:**1847, 1906.

20. Schlagenhaufer: Ueber doppeltbrechende Substanzen in Prostata carcinomen, Verhandl. deutsch. path. Gesselsch. **13,** 1909.

21. Kammer: Ein Fall von Riesenzeller Xanthosarkon und über das Xanthom im allgemeimen, Inaug.-dis. Freiburg, 1909.

and the dura mater (Pick[15]). Smith reports four such cases: (1) on the tongue; (2) on the labia minora; (3) in the parotid gland; (4) and in the neck of the femur.

At present, there are varied theories as to the origin of these xanthomatous tumors. Borst points out that they are often associated with vascular pigmented nevi, and he concludes that the two conditions are anatomically related. Ehrmann states that xanthoma may be associated with multiple lipomas, and Hallopeau and Torsk consider the typical polyhedral and small spindle cells containing lipoid globules as equivalent to embryonal fat cells, which they strongly resemble. Waldeyer believes that they are plasma cells that have become congested with fat. Other writers have attributed the origin to hair follicles, sweat glands and blood vessels and to fatty degeneration of muscle. Ewing points out that not all clinical forms of xanthoma are related to tumors. He suggests the general term xanthomatosis, to apply to the process wherever it occurs and without limitation to a specific anatomic lesion. Bloodgood considers this class of tumors as a special type of angioma or granulation tissue tumor.

Thus, it will be seen that there is a mass of confusing literature on the subject. I shall endeavor to summarize the knowledge we can obtain from the study of a large group of cases—not all xanthomas as we understand the term, and not all exactly similar; but, all so closely related that they seem to belong to a common group and possibly have a common origin. Not any of our other benign connective-tissue tumors suggest themselves as belonging to this group, such as those containing "foam cells," and not any of our true sarcomas have been mistaken for xanthomatous tumors. I use the term xanthoma for lack of a better name.

Therefore, I shall consider tumors which for our convenience have been classified under separate groups. In the laboratory, we have classified under angioma (a benign connective tissue group) hemangioma, lymphangioma, mixed angioma and elephantiasis, which have always been correctly diagnosed and have led to no confusion. Under this group, we have also (1) fibrohemangioma; (2) granulation tissue tumors, which I wish to consider in this paper; (3) tumors of the tendon sheath; (4) tumors of joints, and (5) bursa tumors, which are classified under different groups in the laboratory only for convenience and not because of intrinsic differences in the tumors.

FIBROHEMANGIOMA

We have in this group seventy-six tumors which are very similar macroscopically. They are of the angioma type, but more fibrous than the ordinary angioma tumor. On microscopic study, we note several distinctive differences in the separate cases. In fifty of the cases, there

was no question as to the diagnosis. There is a considerable cellular tissue element embedded in a eosin-staining intercellular tissue with many spindle cells. There are many large and small spaces lined by endothelial cells which show proliferation. There is blood in these spaces; the tumors are very vascular, and there is some blood pigment. We have, then, typical fibrohemangioma. There are no foam cells, no giant cells and none of the characteristics of so-called xanthoma, and there is no suggestion of malignancy. I shall not consider this group.

Fig. 1.—Fibrohemangioma; xanthoma of tendon sheath. Photograph of the gross specimen hardened in alcohol. The mottled light and dark areas may be noted. In the fresh specimen, the tumor looked like bruised area, mottled with every shade of red, brown and black. A photomicrograph is shown in Figure 2.

In seven cases of fibrohemangioma, there was a mistaken diagnosis of malignant neoplasm. I shall refer to these cases briefly.

In one of these cases, a clinical diagnosis of angiosarcoma was made. The tumor was excised and we received a piece for diagnosis. Microscopically, the picture was that of angioma of fibro-angiomatous type and not sarcoma.

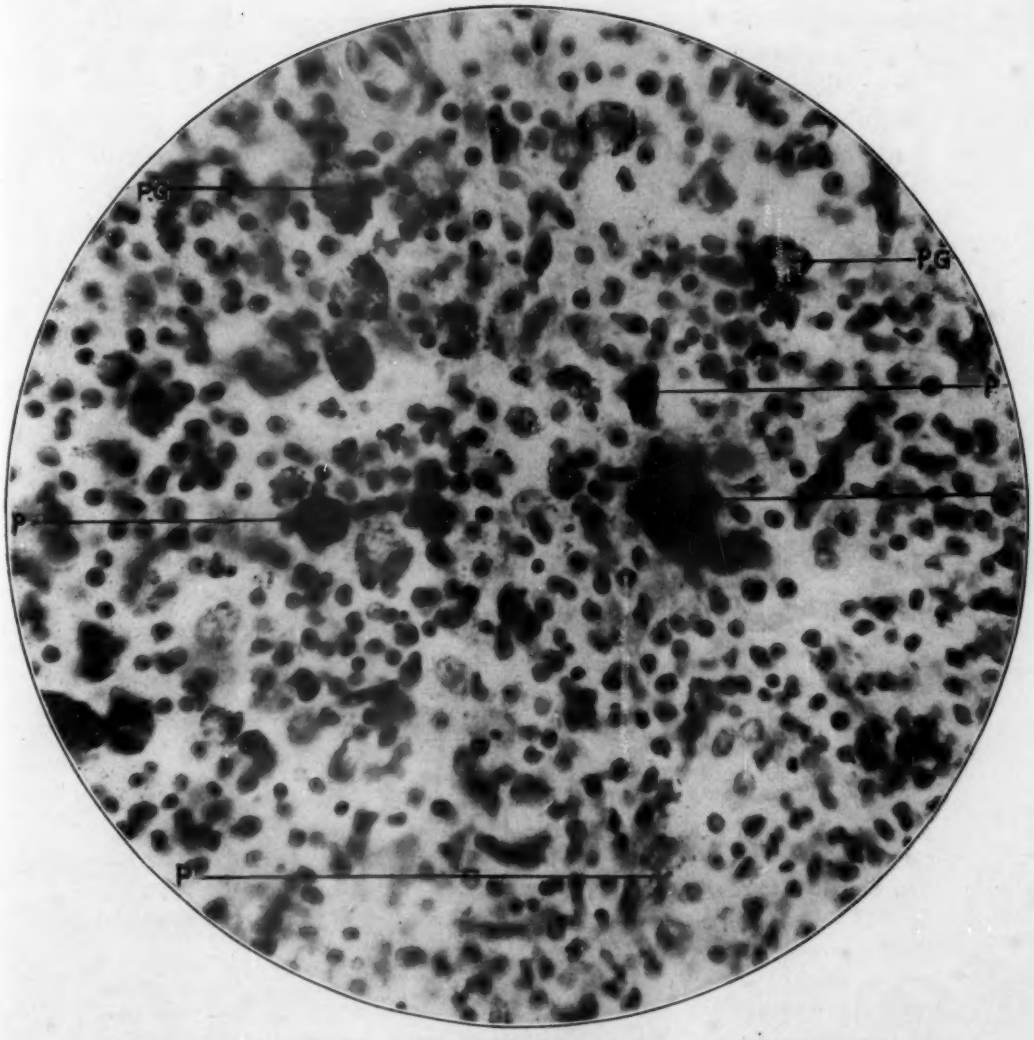

Fig. 2.—Photomicrograph of the most cellular area in fibrohemangioma (xanthoma) shown in Figure 1. *G*, giant cell of the epulis type; *P* and *Pg*, cells filled with blood pigment. Compare with photomicrographs in article by David T. Smith.

In two of the cases, the clinical picture was benign; but from the gross pathology, sarcoma was suspected. Microscopically, the picture was that described as typical for fibrohemangioma.

In two cases, the patient had been operated on previously, and the tumors studied macroscopically and microscopically and diagnosed as malignant neoplasm, the first as a fibrosarcoma and the other as a melanotic sarcoma. In the former case, microscopic study revealed many small cavities lined by endothelial cells. There was much connective tissue and many spindle cells; which gave the appearance of a fibrous spindle-cell tumor. As Bloodgood states, this is a fibrohemangioma and not a sarcoma. The other case was very similar, having many capillary spaces and much pigment and the rather confusing spindle cells. This was also a benign fibrohemangioma.

In the sixth case, three operations had been performed, with recurrence each time. There was swelling of the lower lid for thirty-

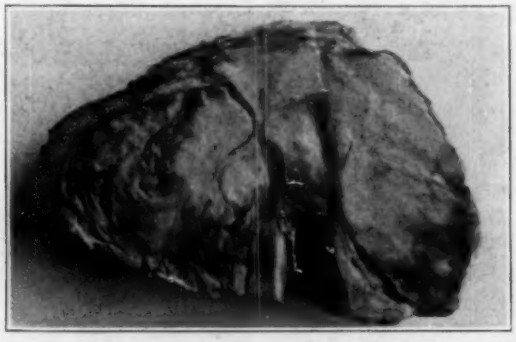

Fig. 3.—Fibrohemangioma (xanthoma), intermuscular, on thenar eminence of the thumb. Compare with Figure 1. The patient was a white man aged 30. The tumor was of fifteen years' duration, with onset after trauma. Exploration operation was performed in 1901, and the surgeon diagnosed sarcoma. The growth was removed incompletely, because the patient refused amputation. In 1923, twenty-two years after operation, there had been no recurrence and there was good function.

nine years in a white man, aged 56. The microscopic picture was that of fibrohemangioma as already described, but not of the xanthoma type. There was rather more proliferation of the endothelial cells than is usual. The patient died while insane, and showed no metastasis.

The seventh case was the only case in which malignancy was questionable. Unfortunately, we do not have the clinical data on this case, and the sections have been lost. Gross pathologic examination revealed a pedunculated skin tumor which on section showed two different features. Part of the tumor was made up of firm, edematous, poorly

defined fibrous tissue which formed a sort of capsule. The greater part of the tumor was soft, friable and brownish red, and mottled with yellowish tissues. There were many blood vessels. Gross diagnosis of perithelial angiosarcoma was made. Microscopic study revealed a very cellular fibrous tissue changing to vascular sarcoma. It was diagnosed as spindle-cell sarcoma in 1901, but we are not able to check the diagnosis. The gross pathology suggests a xanthomatous type of tumor, and the microscopic diagnosis must be discounted. It is probable that this is a benign angiomatous type.

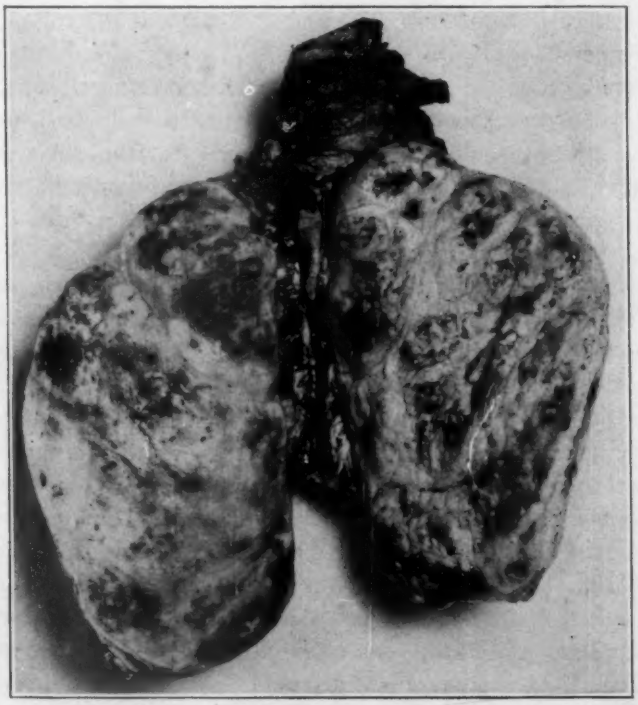

Fig. 4.—Fibrohemangioma (xanthoma), subcutaneous, of the posterior chest wall; gross specimen. Sections show foam cells, blood pigment and giant cells. In 1923, four years after operation, the patient was well.

In these seven, there are no giant cells or foam cells and nothing to suggest xanthoma, but they are somewhat different from the first fifty cases referred to.

The remaining nineteen cases which I have to consider in this connection have the pathologic feature supposed to be typical of xanthoma. From the standpoint of the location of the tumor, age of the patient, duration of symptoms and other clinical findings, there is nothing to differentiate them from the other cases of fibrohemangioma. Although

gross and microscopic study revealed the features which have been considered in the literature as diagnostic of xanthomatous tumors, I shall later show that these features are not pathognomonic of xanthoma.

Macroscopically, these tumors appear as encapsulated brownish or grayish yellow tumors, sometimes more darkly pigmented and often rather vascular. The capsule is of fibrous tissue, and there is considerable fibrous stroma throughout the tumor, sometimes diffuse throughout the tumor and sometimes sparse in one part and dense in other parts, giving the appearance of a fibrous spindle-cell tumor. The consistency is firm and it usually resists when cut, but in a few cases, the angiomatous characteristics are prominent, and the tumor is somewhat spongy.

Microscopically, the appearance seems rather distinct. The tumor is very cellular and presents at least two characteristics. First, the fibrous connective tissue usually divides the tumor into lobules or this tissue may appear as a dense spindle-cell fibrous tissue which has been mistaken for sarcoma. Either interspersed among the fibrous strands or separated into lobules, are masses of so-called characteristic foam cells. These cells look as if the nuclei were appearing in uniform vacuolated areas. These cells have been discussed above, in a discussion of the literature, and I shall have more to say about them subsequently. They are supposed to be characteristic of xanthoma, yet they appear in many other conditions of disturbed metabolism or infection, and according to the literature only about 50 per cent. of the xanthoma contain them. In our series, foam cells were present in only nine of twenty-one cases which seemed to be xanthoma. Broders [14] found them in 64 per cent. of his seventeen cases. There are other characteristics microscopically. Large foreign body giant cells appear in varying numbers in all of these seventeen cases. These giant cells are identical with foreign body giant cells found elsewhere; for instance, in giant cell tumors of bone and in infectious conditions. There is noted also an endothelial proliferation and varying numbers of capillaries; which suggests that these xanthomatous tumors are closely related to nevi, histologically certainly and also possibly from the standpoint of development. There is generally some round-cell infiltration and considerable blood pigment, which is not true cell pigment, but is extraneous pigment from destroyed blood.

Clinically, there is nothing characteristic about these tumors. There is no constant etiologic factors. Broders states that injury seems to play an important part in the origin of xanthic tumors. He thinks, also, that infection plays a part. In only three of our nineteen cases does trauma seem to play an important etiologic part. One case was congenital. In three cases, there was trauma after the appearance of

the tumor, with infection, which brought the patient into the hospital, but this seemed to have no connection with the causation of the tumor. In five of our cases, the clinical data was incomplete.

These seventy-six cases were all benign and have not recurred nor metastasized since local excision. I shall speak further of treatment when I consider all my five groups of cases together, for they all should be given the same treatment.

FIBROMA OF THE TENDON SHEATH

In this group, we have thirty cases of tumors that have masqueraded under many different names, and even now it is doubtful what names should be attached to some of these cases. But I shall try to establish the point that it makes no difference what we call these separate tumors, for they all belong to one main group. Not any of the older growths were diagnosed as xanthoma; but further study has led us to believe that thirteen have the characteristics on which the diagnosis of xanthoma might be based. Yet, they do not differ essentially from any other members of this group. Although previously diagnosed as malignant neoplasms, they all thirty are apparently benign, because the patients are well after local operation. Therefore, it seems wise to consider the group as a whole and to point out the reasons for believing that some of the neoplasms might be considered of xanthomatous type. Later, I shall compare the whole group with the other groups considered in this paper.

Apparently, these tumors are relatively rare. The first case came into the laboratory in 1896, and since then there have been only twenty-nine cases; but recently more cases have been diagnosed benign; which indicates either that these cases formerly diagnosed as sarcoma were filed with the malignant cases and were not followed, or that they were not recognized, and healed without treatment. The former theory is more plausible.

As observed repeatedly in the literature, these tumors are generally benign when below the elbows or knees and probably malignant when above. In several of our cases, the exact site of the tumor was not noted, but in all the cases of which the records are complete, the tumors were situated below the wrist or below the ankle.

Age is apparently of slight importance. There was one case in which the tumor was congenital. The age of onset in the other cases ranged from 5 to 56 years. Duration of symptoms was from three weeks to twenty years; and those of shorter duration were just as benign histologically and clinically as those of longer duration.

Trauma seems to have been an etiologic factor in only five cases; but in half of the cases, no record was made as to whether or not

there was definite history of trauma. Therefore, in this group, we agree with Broders that trauma is present in about one third of the cases.

In the clinical picture, there is nothing very characteristic. The tumor is slow growing, and generally gives only slight pain and discomfort. Only two of our cases were multiple.

The gross picture is not always convincing. The tumors are all fibrous and encapsulated, and may be either lobulated or smooth. Some are uniformly fibrous and are recognized as fibroma, or, quite often, as fibrosarcoma. Others have a distinct mottling with yellow spots, which are sometimes described as having the appearance of fat; and one was spoken of as myxomatous in appearance. It is this latter group that I shall call xanthomatous tumors, for they present the characteristics ascribed to these tumors; but I doubt the wisdom of considering them as a separate and distinct class of tumors. In this group, there are thirteen cases which are xanthomatous in the gross and seventeen which appear as simple fibroma.

The striking thing about the microscopic study of these thirty cases is the fact that they are all strikingly similar despite the macroscopic differences. There are also many pictures which in these cases simulate those of tumors of the fibrohemangioma group. In all the cases, the stroma was fibrous and contained spindle cells. The presence or absence of giant cells is interesting. In eleven of the thirteen cases, which in the gross appeared as xanthoma, there were typical giant cells, and in two cases we cannot restudy the sections. In the seventeen cases, there were in most the same sort of giant cells. Foam cells were found in only three of the thirteen cases, but allowance must be made for the fact that, in some of the cases, a description was made years ago and the sections have been lost. Round cells were a feature in nearly all the cases, without relation to the gross appearance. Blood pigment was present in nearly all the cases. Thus, we believe that in this group there is no one feature which separates the xanthomatous tumors from the other tumors of the group.

Treatment was practically the same in all the cases; excision of the local growth. We had one amputation in a case of recurrence after a previous excision. Five of the patients had a recurrence after local excision, but none died from the effects of the neoplasm. In one case, a congenital tumor excised when the patient was 13 years old promptly recurred. The tumor was completely excised again at age of 20, and the patient was well without recurrence eight years afterward. In one case, the growth was excised and diagnosed benign tendon sheath tumor, and on recent study it seems to be of the xanthoma type. It recurred and was removed at another clinic and diagnosed tuberculosis. It must be remembered that the giant cells found in these tumors

may be confusing. In another case, the growth recurred after local excision; the finger involved was amputated, and the patient was well after two years, and was then lost sight of. This case was previously diagnosed as sarcoma. There was some doubt as to the diagnosis, but we believe it was a benign fibroma of the tendon sheath. Of the other two growths which recurred after local operation, one was xanthomatous and the other a fibroma which was previously called sarcoma. These were old cases, but we do not know the ultimate outcome.

I shall speak further of these cases when I consider all the cases together.

GRANULATION TISSUE TUMORS

There are twenty-six cases in this rather heterogeneous group of cases, which are distinguished by being very cellular tumors with what appeared to be granulation tissue. On analysis, they resolve themselves into these groups: foreign body type (two cases); tuberculous type (one case); associated with diabetes (one case); primarily infectious in origin (six cases); associated with umbilical hernia (one case); definitely associated with trauma (three cases); of questionable type (two cases); angiomatous type (five cases); xanthomatous type (one case), and cases mistaken for malignant neoplasms (four cases). Although it might seem from this that we are dealing with many kinds of tumors, they are all very similar.

The fact of primary importance in this group of cases is that we are dealing with a benign tumor which is very similar in many ways to the two groups with which we have already dealt. There are five cases of angiomatous type and one is xanthoma. The tumors are all very cellular, and some of them have been mistaken for malignant neoplasms.

Further analysis shows that in fourteen of these cases the history of injury, infection or other clinical findings is such that we know at once that we are dealing with a granulation tissue tumor, and this was confirmed by microscopic study. I shall dismiss these cases without further comment, but there are other cases in this group worthy of further study.

In five of the cases, there was a tumor which was angiomatous in type, and the gross appearance was that of a vascular, but firm tissue. Microscopically, there were vascular spaces and proliferation of the endothelial cells and many spindle cells. This is the picture we see in fibrohemangioma, but there were also areas in which the picture was that of granulation tissue, and a few giant cells are found.

In the one case in which xanthoma was diagnosed, there was nothing distinctive in the clinical or gross picture. Microscopically, there was

a fibrous stroma containing many cellular elements, giving it the appearance of granulation tissue or angioma. There were two types of intercellular areas: one taking the eosin stain and the other which took no stain and suggests myxomatous areas. There were hemorrhagic areas, and lymph cells and leukocytes which suggested infection. There were a few giant cells, much pigment, proliferating endothelial cells and a few foam cells. The number of giant cells and the amount of pigment was less than in other cases of xanthoma. In this case, complete removal was advised.

In four of the benign granulation tissue tumors, there was a question of malignancy somewhere in the course of the case. In one case in which there was a large nodule on the lower part of the leg for three and one-half years and ulceration for six months in a woman, aged 73, at operation a tumor 5 inches (12.5 cm.) in diameter was removed, with a skin margin. The gross impression was carcinoma. Microscopically, there was no evidence of carcinoma, but the growth was made up of a lymphoid type of cell which was larger than the ordinary type of lymphocytes and smaller than the blood vessel endothelial cells. This was either a sarcoma or a granulation tissue tumor, and Dr. Bloodgood considered it a benign granulation tissue tumor. In the second case, a patient, aged 25, had had a firm tumor in his cheek for three months. Macroscopically, this was a fibrous tumor and microscopically it was a fibroma, although it was mistaken for sarcoma. The third case was clinically benign, but microscopically there was the same picture as in the case of the woman, aged 73, but it was considered to be benign, and in both these cases the subsequent history favors benignancy. The fourth case was diagnosed clinically as a malignant mole. Pathologically, it was not a mole and was not malignant, but was a granulation type of tumor.

In summary, then, all these cases are benign and are generally recognized as such, but they are similar to the other types of cases I have under consideration. Local treatment was given in all cases, and all patients are cured, without recurrence.

BURSA

I have restudied all our fifty-three cases of bursa affections to see whether I could find there anything similar to the other tumors. I shall dispose with this group very briefly.

Forty-seven of these cases come under the usual types of bursitis. Three of the cases are unusual types of bursitis. Of these, one case was a syphilitic bursitis and two of the cases showed calcification in a bursitis in which, in the gross, there was much yellow tissue similar to the xanthomatous tumors, and, microscopically, there were many giant cells but they have no further relation to xanthoma. Another

case was interesting because it was diagnosed clinically as sarcoma of the thigh, but microscopically there was found a bursitis developing on a preexisting exostosis. Although this condition was quite benign, amputation had been advised. Another interesting case is one in which there was a tumor in a tendon sheath in connection with a bursa. It was diagnosed by one pathologist as perithelial angiosarcoma and by another pathologist as benign. Possibly, it is a case of granulation tumor occurring in a bursa.

The only case in connection with a bursa which has a definite relation to the class of cases I have under discussion is one which came into my hands today. A patient, aged 48, was operated on for prepatellar bursitis. Macroscopically, the tumor presented an appearance almost typical for xanthoma, with mottling of gray fibrous tissue with yellow spots. Microscopically, the tumor was edematous fibrous tissue with granulation tissue, and the color was due entirely to blood pigment. No giant cells, foam cells or any evidences of xanthomatous tumors were seen despite the gross appearance.

TUMORS OF THE JOINTS

I have also restudied the cases of tumors of the joints to see what connection there is between these tumors and the groups under discussion.

We had but eleven cases of tumors of joints (all of the bones) not including cases in which the joint is involved secondarily to bone tumors. Of these cases two were chondromas, one myxoma, two lipomas, one fibroma and four xanthomas. I shall refer briefly to the last four cases.

Case 1 showed foam cells, capillary angioma, giant cells and pigment. We do not have the clinical records. Case 2 (Hartman's) was a typical "xanthoma," which Hartman has reported.[15] Case 3 was a giant cell fibrohemangioma or xanthoma. We do not have the clinical records in this case. In Case 4, operation was performed by Deaver on a woman, aged 21, who had had pain in the knee for six months, with swelling. At operation, necrotic tissue was found below the patella, and the affected tissue was removed. Microscopically, there were many giant cells, which at first suggested giant cell tumor of bone, but the tissue in which the cells were embedded was different. The cells were smaller and there were many spindle cells and endothelial lined blood spaces. There were no foam cells.

This tumor was removed in 1914, incompletely, but the patient was well in 1920. This case was treated with radium subsequent to operation, and cure after incomplete removal might be attributed to the radium; but we had two tumors of this type in tendon sheaths (one

of the hand and one of the foot), in which it was known that the tumor was incompletely removed, but the patients remained well without any subsequent treatment.

SUMMARY

We have, therefore, among these 196 cases, 137 cases, in five groups, which are in many respects very similar and which we believe should be considered together, at least theoretically, for classification and treatment.

The fibrohemangiomas present a typical picture, as do the fibromas of the tendon sheath. The granulation tissue tumors are often confusing, and in the bursae we may find tumors that are of this granulation tissue type. Xanthoma is to be found in the knee joint and here presents the same picture as the other tumors of the group. A larger part of the tumors of tendon sheath and fibrohemangioma might be called "xanthoma." On the other hand, seven of the thirty cases of fibroma of the tendon sheath show characteristics of granulation tissue; and among the granulation tissue tumors, five present the characteristics of the fibrohemangioma. We do not suggest any name for this confused group of cases unless they might be called "endotheliogranulomas."

Thus, the tumors may appear in the tendon sheaths, usually below the wrist and the ankle; in the subcutaneous tissue, in any part of the body but usually below the knee and ankle, and bursa or joints, usually the knee. They may occur at any age, usually grow slowly, and the duration of symptoms is generally in terms of years. Clinically, these tumors are sometimes called malignant. We have no evidence that the roentgen ray is of value in diagnosis. The gross pathologic condition is occasionally confused with malignant neoplasms.

I have considered microscopic pictures in the separate cases. I shall review the features briefly. The characteristic eosin-staining intercellular tissue varies in density and often has spindle cells. The cellular elements are many. The spindle cells often resemble sarcoma cells. Large round cells with blood pigment are usually present. The pigment in these cells is always exogenous. Blood pigment may also appear in the intercellular tissue. Giant cells may or may not be present without adding any particular significance as regards prognosis, etc. So-called foam cells or xanthoma cells may or may not be present. They are most often absent in our cases, and I doubt that this is ever evidence of a specific type of neoplastic cell; and at least it is not specific for the xanthoma tumor. Proliferation of endothelial cells is often noted. Blood vessels and capillaries may or may not be increased in number. There is an absence of any histologic features which can be definitely considered as evidence of malignancy.

The question of operation is interesting, local excision being performed in practically all our cases. Fifteen per cent. of our tendon sheath cases recurred, but the patients remained well after subsequent operation. When they occur in the subcutaneous tissue, they never recur. When in the synovial membrane of the larger joints, they have a tendency to become malignant. I have pointed out that two of our patients remained well after incomplete local excision without subsequent treatment.

The only difficult point is to differentiate the benign tumors from sarcomas and carcinomas. Taking the clinical evidence into consideration, the final diagnosis must be made from the microscopic study, and one must be familiar with both the benign and the malignant tumors which sometimes closely simulate one another.

METHOD FOR MAKING A DIFFERENTIAL DIAGNOSIS BETWEEN XANTHOMATOUS AND MELANIN TUMORS FROM FROZEN SECTIONS*

BASED ON A STUDY OF ONE HUNDRED AND THIRTY XANTHOMATOUS TUMORS AND TWO HUNDRED MELANIN TUMORS

DAVID T. SMITH, M.D.

BALTIMORE

The surgical pathologist is frequently confronted with the problem of making a differential diagnosis between xanthomatous tumors containing blood pigment and a true pigmented tumor of the melanin type. Xanthomatous tumors are always benign, although they may simulate sarcoma; while malignant melanin tumors are among the most fatal known to surgery. In some cases, the diagnosis is very easy, especially when we have the clinical history and examination; but in others it may be extraordinarily difficult.

When examined under the low power microscope, or even under the high dry, the sections from the two types of tumors may appear identical. We are not infrequently left in doubt even after obtaining the staining reaction for iron, because it is not uncommon to have hemorrhage in tumors of the melanin type. Neither can we always rely on the history and location of the tumor, because there are a number of xanthomatous tumors in this laboratory just beneath the skin, which is a frequent site for melanin tumors. On the other hand, we have one perfectly typical melanin tumor originating from a tendon sheath, which is a favorite location for xanthomatous tumors. Considerable difficulty is frequently encountered in making a diagnosis from a section of a pigmented gland, which may contain metastases from a pigmented tumor, old blood pigment or a combination of both.

Coincidentally with Garrett's study of xanthomas, I made a clinical and pathologic study of all the tumors of the melanin type in the surgical pathologic laboratory of the Johns Hopkins Hospital. At the suggestion of Dr. Joseph Colt Bloodgood, a comparative study of the pigment in the two classes of tumors was undertaken, for the purpose of finding criteria by which one could tell at the time of operation, from a frozen section, whether the tumor was a xanthoma or a true melanin tumor.

The results were very encouraging, and it seems possible in practically all cases to tell from the morphology of the cell and the appear-

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*From the Surgical Pathological Laboratory, Johns Hopkins Hospital.

*This study was made on the same group of tumors that Dr. Charles A. Garrett reported in the preceding article.

ance of the pigment whether the tumor in question is a true pigmented tumor of the melanin type or a xanthoma. This differentiation is both logical and practical when we consider the origin and cytology of the cells in the two classes of tumors.

From a review of the literature and from a study of the cases in this laboratory, it is evident that at least two groups of tumors have been included under the general term Xanthomas. In the first group, the color is due to the coloring matter contained in the lipoid substance which fills certain of the cells. In this group are (1) xanthoma palpebrarum, (2) xanthoma diabeticorum and (3) xanthoma multiplex; all of which contain the "foam" cells. These tumors have been studied very thoroughly by a number of workers (Johnston,[1] 1895; Pollitzer,[2] 1899; C. Smith,[3] 1912). They contain neither blood pigment nor giant cells, and in general seem more closely related to the inflammatory and degenerative processes than to real new growths.

In the second group, the color is largely due to blood pigment that is found in the cells of the tumor, although in some cases there is additional coloring from the lipoid substances contained in the "foam" cells. They are benign connective tissue tumors containing much blood pigment and many giant cells, arising generally from tendon sheaths or about joints. Tourneau,[4] in 1913, collected fifty-four cases from the literature. Reid and Landois [5] reported four cases from this clinic in 1914. The next year, Stewart and Flint [6] collected seventeen new cases from the literature. Broders,[7] in 1919, reported seventeen cases from the Mayo Clinic. During the past year, Garrett, working in this laboratory, has made a thorough study of this group of tumors.

No difficulty in diagnosis is offered by xanthomas of the first group because the lipoid substances containing the color are dissolved out by the action of our routine clearing reagents. It is the second group, which contains granules of blood pigment in the cells, that it is difficult

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1. Johnston, James C.: Xanthoma Diabeticorum—Its Place Among the Dermatoses, J. Cutan. Genito-Urin. Dis. **13**:401, 1895.

2. Pollitzer, S.: The Nature of the Xanthomata, New York M. J. **70**:73, 1899.

3. Smith, C.: The Histology and Nature of the So-Called Foam-Cell Tumors, Surg., Gynec. & Obst. **14**:551, 1912.

4. Tourneau, J. R.: Les sarcomes des gaines tendineuses, Rev. de chir. **47**:817, 1913.

5. Reid, Mont, and Landois, Felix: Das pigmentierte riesenzellenhaltige Xantho-Sarkom der Extremitäten, Beitr. z. klin. chir. **95**:56, 1914.

6. Stewart, M. J., and Flint, E. R.: Observations on the Myeloid Tumor of Tendon Sheaths, Brit. J. Surg. **3**:90, 1915.

7. Broders, A. G.: Benign Xanthic Extraperiosteal Tumor of the Extremities Containing Foreign Body Giant Cells, Ann. Surg. **70**:574 (Nov.) 1919.

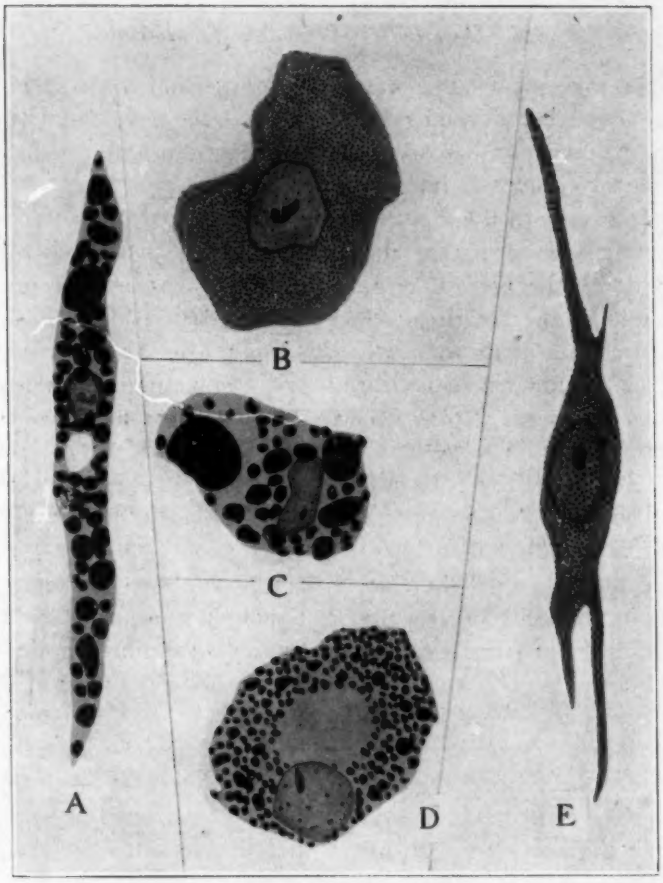

Fig. 1.—Camera lucida drawing (× 2,000): *A*, connective tissue cell from the stroma of a malignant pigmented mole. This cell has taken in large amounts of melanin pigment, liberated by the death of the true pigmented tumor cells, and has clumped it into masses of irregular size and shape. The pigment in this cell would not give the iron reaction because melanin contains no iron. Figure 2 is a photomicrograph of the same tumor. *B*, a camera lucida drawing of one of the cells, from a malignant pigmented mole arising from the skin. The granules here are fine, diffuse and evenly distributed throughout the cytoplasm. Some are seen as short rods. These are melanin pigment granules and would not give the iron reaction. Figure 2 is a photomicrograph of the same section from which this cell was drawn. *C*, a cell from a benign connective tissue tumor of the xanthoma type. This cell has taken in large masses of blood pigment which would give the iron reaction. Figure 3 is a photomicrograph of the same section. *D*, a cell from a benign connective-tissue tumor of the xanthoma type. The clear area in the center of the cell is a giant centrosphere. The granules of blood pigment are in clumps of irregular size and shape. They are smaller than those in *A* and *C* and yet much larger and more irregular than the melanin granules seen in B and E. The granules in this cell, like those in Figure 3, gave the iron reaction. Figure 4 is the photomicrograph of the same section. *E*, a pigment cell from a malignant pigmented tumor of the spindle-cell sarcoma type, which arose in the subcutaneous tissue. It shows branching processes like the chromatophore of the lower animals. The cell is filled with fine, round granules which would not give the iron reaction. Figure 5 is a photomicrograph of the same section.

to differentiate from true melanin tumors. But the diagnosis can be made rapidly and accurately if we understand the origin and appearance of the granules.

The melanin pigment granule is endogenous in origin and is formed in the cytoplasm of the cell (D. T. Smith,[8] 1920). It does not contain iron (Abel and Davis,[9] 1898) and will not give the iron reaction. These granules are individual discrete bodies, all of about the same size, shape and color in a given cell (Fig. 1, *B* and *E*). Their distribution throughout the cytoplasm is strikingly regular, and in general they are much smaller than those granules found in the cells of the xanthoma (Fig. 1, *C* and *D*). Granules having these characteristics are found in cells belonging to two distinct types of tissue—epithelium and mesothelium. The first type of cell is found normally in the retina and in the basal layer of the skin. The granules in the retinal cells are quite long (0.5 to 1 micron) and definitely rod shaped. Those in the skin are much smaller and have only a slight tendency to be rod shaped. The second type of cell is long and spindle shaped with branched processes resembling the chromatophore of lower animals (Fig. 1, *E*). It occurs in the choroid of the eye, in the membranes of the brain, and along nerve trunks. The granules in these cells are always round (Fig. 1, *E*). When malignant changes begin in either the epithelial or the chromatophore types, the granules become smaller in size, often appearing as fine diffuse dustlike particles.

The pigment granules in the xanthoma are hematogenous in origin and give the iron reaction except in cases of very old hemorrhage. They are, of course, foreign bodies in the cytoplasm of the cells. During some experimental work on the ingestion of foreign pigment by tissue culture cells (D. T. Smith,[10] 1921), it was found that when cells took in pigment, the cytoplasm reacted in such a manner as to collect these foreign bodies into clumps of irregular size and shape. Subsequent to the clumping, vacuoles were formed about each mass of pigment. It was found that practically all types of cells reacted in this manner (epithelial, connective tissue cells, clasmatocytes, white blood cells, cells of the intestines, liver, lung, spleen, kidney, etc.) except red blood cells, nerve cells, and muscle cells. The different cells varied somewhat in the number of granules which they contained after exposure for a given length of time. The clasmatocytes (macrophages, connective-tissue

8. Smith, D. T.: The Pigmented Epithelium of the Embryo Chick's Eye Studied in Vivo and in Vitro, Bull. Johns Hopkins Hosp. **31**:239 (July) 1920.

9. Abel, J. J., and Davis, W. S.: On the Pigment of the Negro's Skin and Hair, J. Exper. Med. **1**:361, 1896.

10. Smith, D. T.: The Ingestion of Melanin Pigment Granules by Tissue Cultures, Bull. Johns Hopkins Hosp. **32**:240 (July) 1921.

wandering cells) were the most active. They collected large masses of pigment, sometimes filling the cell so completely that the nucleus was obscured. The fibroblasts and the white cells of the blood were only a little less active. The nature of the pigment made no difference in the reaction, as melanin pigment from various sources, carbon particles, dye granules and blood pigment were all taken into the cell with equal avidity and clumped in the characteristic fashion. There can be little doubt that the pigment which is found in the cells of xanthomas is taken in the same manner.

There is really nothing diagnostic about the type of cells that contain the pigment in the xanthomas. It may be found in the clasmatocytes, the white blood cells of various types, fibroblasts, endothelial cells and even the giant cells. The clasmatocyte (Fig. 1, *C* and *D*) is the most constant and the most striking of all. In some tumors, the granules seem to be arranged about a clear spherical structure which is most probably a giant centrosphere (Lewis, 1920). This occupies the center of the cell and pushes the nucleus well to one side. The nucleus is often so obscured by overlying granules that one may mistake the giant centrosphere for the nucleus when examining the section under the low power microscope. This giant centrosphere was found in nine of seventeen typical xanthomas (D. T. Smith,[11] 1922). In seven of these cases, it was associated with foam cells. In only one tumor were foam cells present, without the giant centrosphere, and in that case the cells containing the pigment had disintegrated. The presence of this body is probably to be regarded as evidence of degeneration in the tumor and it is much more diagnostic of xanthoma than foam cells are.

It is seen from the foregoing description that the pigment in the xanthomatous tumor is absolutely different in origin and morphology from that in the melanin tumors; and generally it is a simple task to determine, with the aid of the oil immersion lens, whether the pigment contained in the cells is in clumps of irregular sizes and shapes (Fig. 1, *A*, *C* and *D*), or in fine, diffuse, evenly distributed granules (Fig. 1, *B* and *E*). Some of the xanthomas are very fibrous, others are cellular and have the appearance of granulation tissue tumors. Still others show various combinations of the two. The fibrous xanthoma must be differentiated from fibrous melanin tumors which originate from the long branch type of pigment cell (Fig. 5). Three of our melanin tumors of this kind were originally included in the xanthoma group. In the more cellular xanthoma, in which the pigment is located largely in cells of the clasmatocyte type (Fig. 4), it is necessary to rule out melanin tumors of the epithelial type (Fig. 2).

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11. Smith, D. T.: Giant Centrospheres in Xanthomatous Tumors, Bull. Johns Hopkins Hosp. **33**:342 (Sept.) 1922.

Fig. 2.—Photomicrograph of a malignant pigmented mole which arose from the skin. When examined under the low power, the pigment all seemed to be in the connective tissue strands which formed the stroma of the tumor. Figure 1 *A* shows a cell from this stroma. When the tumor cells were examined with the high power it was seen that most of them were filled with fine diffuse evenly distributed pigment granules. Figure *B* shows one of these tumor cells.

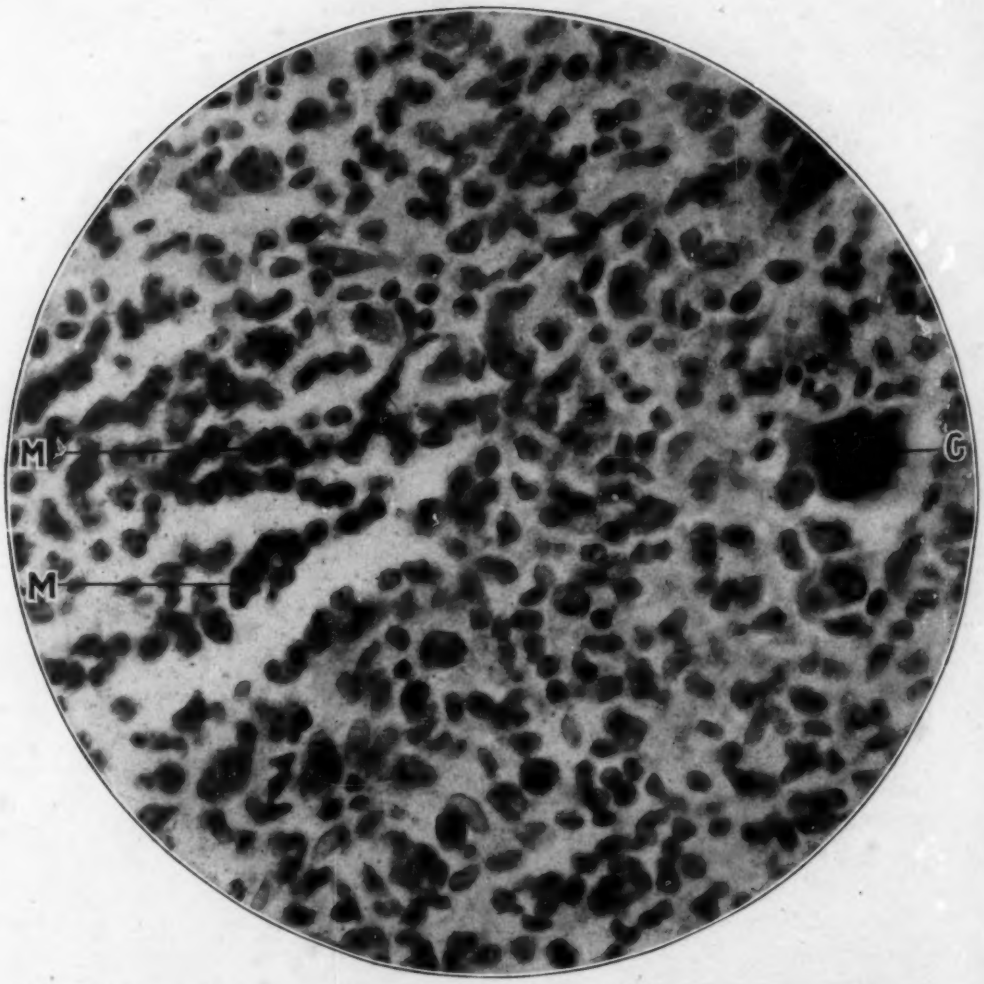

Fig. 3.—Photomicrograph of a benign connective-tissue tumor of the xanthoma type. One giant cell of the epulis type is seen (*g*). Some of the cells on the opposite side of the figure show masses of pigment (*m*). Figure 1, *C* is a drawing of a cell from this section, which was filled with such masses.

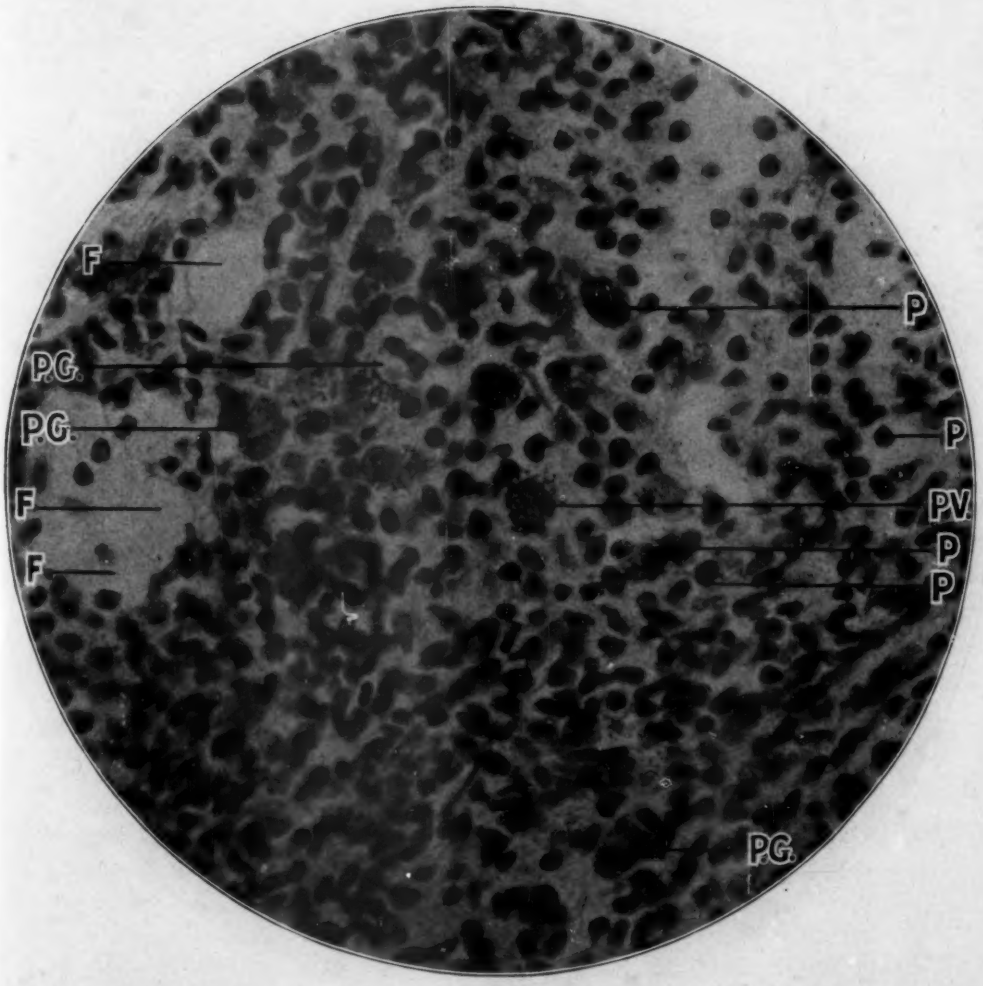

Fig. 4.—Photomicrograph of a benign connective-tissue tumor of the xanthoma type. The large clear cells with the small nuclei and the finely reticulated cytoplasm are foam cells (*f*). There are many pigment cells (*p*) scattered throughout the section. Some of these cells contain vacuoles in the cytoplasm as well as pigment (*pv*). Other pigment cells show giant centrospheres (*pg*). Figure 1, *D* is a drawing of one of these cells which contained a giant centrosphere.

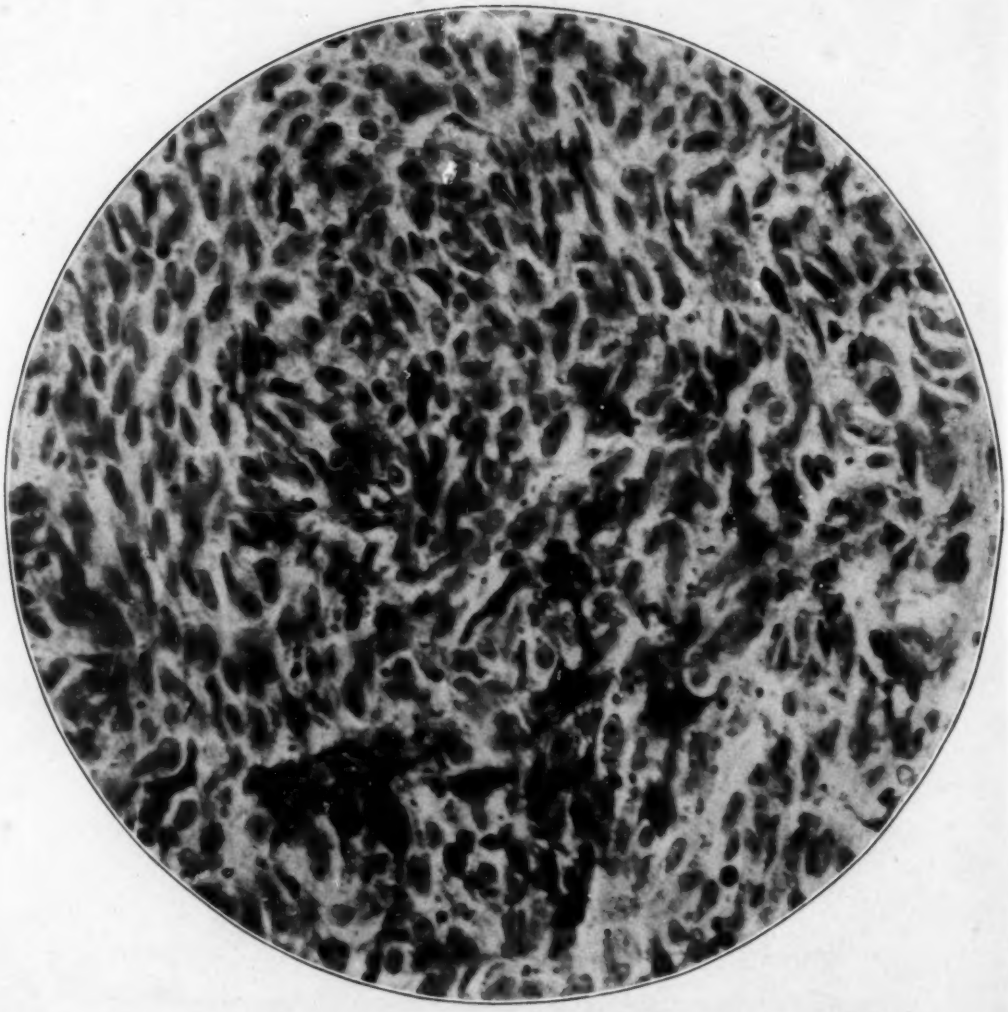

Fig. 5.—Photomicrograph of a malignant pigmented tumor of the spindle-cell sarcoma type which arose in the subcutaneous tissue. Some of the cells are heavily pigmented; others contain very little pigment. Figure 1, *E* is a drawing of one of these pigmented cells.

Theoretically, the differentiation between the two types of pigment tumors is exceedingly simple. Practically, it is just as simple in the majority of cases, but there are a few complicating factors which it is well to bear in mind. When there has been hemorrhage into a melanin tumor, cells containing blood pigment (Fig. 1, *C* and *D*) will be found mixed with true pigment cells (Fig. 1, *B* or *E*), and perhaps even with giant cells. In that case, the diagnosis depends on identifying the cells containing the true endogenous pigment. Another confusing condition is produced by the death of some of the cells containing melanin pigment. This pigment is not autolyzed with the death of the cell (Smith [8]) but is liberated and subsequently taken in by cells constituting the stroma of the tumor (Fig. 1, *A*). This offers no difficulty when the physiology of the process is considered. Occasionally a xanthoma is obtained into which a fresh hemorrhage has occurred. In this case, some of the cells may seem to be filled with a diffuse pigment; but when they are examined carefully under the oil immersion lens, it is seen that the coloring is due to homogeneous masses of unchanged hemoglobin which has just been taken into the cells. This picture is quite different from that of the cells of the true melanin tumor, with their minute clear-cut, sharply outlined granules. Finally, when there is a doubt, the suspicious cells should be compared directly with the cells of a known melanin tumor. These points of differentiation have been given with special reference to xanthomatous tumors, but they will serve equally well to differentiate true melanin from ingested pigment in any tumor or any tissue.

SUMMARY

In general, we may say that the color found in any particular tumor may be due to colored lipoid substances, true endogenous melanin pigment, blood pigment or the various combinations of the three. The lipoid substances are dissolved by the clearing reagents used in the routine methods and offer no difficulty in the diagnosis. It is the differentiation between tumors containing blood pigment or exogenous pigment and those containing true endogenous melanin pigment that causes the difficulty; and this disappears when we remember that blood pigment and exogenous pigments are found in the cells in the form of granules of irregular sizes and shapes; while the melanin pigment is always in the form of fine, diffuse, evenly distributed granules, all of about the same size, shape and color in a given cell.

The presence of pigment of hematogenous origin is not diagnostic of any particular type of tumor, as hemorrhage may occur anywhere. It seems to occur more frequently in the xanthomatous tumors and in the giant cell tumors of bone.

TWENTY-THIRD REPORT OF PROGRESS IN ORTHOPEDIC SURGERY *

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AND

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CONGENITAL DISLOCATIONS

Congenital Dislocations of the Hip. Open Operation.—Galloway [1] describes in detail his operation for the reduction of congenital dislocation of the hip, which he has been strongly advocating since the publication of his paper in 1920. Sherman, many years previously, advised a somewhat similar attack, but we believe that before his death he grew somewhat less enthusiastic concerning the method. Galloway says that the operation has been further developed and improved (since his paper of 1920) until now the results in *young children* are so uniformly satisfactory that he no longer approaches these cases with a feeling of dread or uncertainty, but with confidence that the treatment is simple, safe and practically certain to result satisfactorily. He considers the closed method of Denucé successful, but unfavorable when compared to the open method, because of the greater length of time required to attain the desired result. Galloway does not publish any conclusive review of his own end-results.

[ED. NOTE.—Until Galloway publishes a considerable series of end-results demonstrating not only as high a percentage of successful reductions and complete functional restorations, but also a smaller percentage of deformations of the head and neck than have already been reported after the closed reductions in young children, the open method should not be generally undertaken. We should not forget that several able and careful surgeons have employed and even advocated an open method, and have subsequently abandoned the procedure because of the operative risk and the frequent imperfect recovery of function.]

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* This Report of Progress is based on a review of 447 articles selected from 909 titles dealing with orthopedic surgery, appearing in medical literature between July 1, and Dec. 22, 1923. Only those papers which seem to represent progress have been selected for note and comment.

1. Galloway, H. P. H.: Surg., Gynec. & Obst. **37**:674 (Nov.) 1923.

Deformity of the Head of the Femur in Old Congenital Dislocation.—Heitzmann [2] has had the opportunity to examine histologically a much deformed head of the femur of an 8-year-old girl with bilateral congenital dislocation. The examination was made one year after a reposition of the left hip. The right side was not reduced, and therefore a comparative study of the two heads was possible. Brandes and others have maintained that the changes so often observed in the upper end of the femur after "successful" reductions are identical with those seen in coxa plana (Legg-Calvé-Perthes). Heitzmann does not believe that this opinion is correct. He concludes that the changes which he found were the result of a traumatic deforming arthritis. His finding of incomplete fractures of the spongy head was of special importance in this connection. He considers the late roentgenograms most misleading and his histologic examination conclusive.

Contraction of the Iliopsoas in Congenital Dislocation of the Hip.—Fraenkel [3] is convinced that the contraction of the iliopsoas muscle offered the chief obstruction to reduction in nine cases of congenital dislocation of the hip. Four of these cases were in adults or in adolescents. In three of the cases, little manipulation was necessary to reduce the dislocation after an extra-articular tenotomy of the iliopsoas tendon had been performed. In other cases, he was obliged to employ more extensive manipulations. He considers preliminary traction of advantage.

Arthrogryposis Multiplex Congenita.—Stern [4] reports four cases of congenital multiple incomplete fibrous ankylosis of joints of the extremities. The maxillary and vertebral articulations were unaffected. The position of extension of the arms and legs was not due to muscle or tendon contractures. The chief characteristics of this condition seem to be a limitation of motion in all the affected joints, an inward rotation of the arms, an outward rotation of the thighs, a flexed position of the wrist and hands and a twisting of the feet. The elbows and knees appear fusiform. A few degrees of perfectly free motion remain in the affected joints, but beyond this both active and passive motion is possible. The muscular development is poor, but in none of his cases was any real loss of nerve or muscle function demonstrable. By osteoclasis, osteotomy and physiotherapy, many of the deformities were relieved, but the individuals did not become self-supporting. The etiologic theories are (1) maldevelopment of the ovum or the fetus; (2) intra-uterine pressure and malpositions; (3) intra-uterine peri-

2. Heitzmann, O.: Klin. Wchnschr. **2**:1982 (Oct. 22) 1923.
3. Fraenkel, J.: Deutsch. Ztschr. f. Chir. **176**:84, 1922.
4. Stern, W. G.: Arthrogryposis Multiplex Congenita, J. A. M. A. **81**:1507 (Nov. 3) 1923.

arthritis. The author does not consider these cases achondroplastic in type, and urges a more general reporting of them in order that their relative frequency may be established and their treatment more carefully considered.

TUBERCULOSIS

Tuberculous Osteoarthritis in Infants.—Broca [5] believes that tuberculous arthritis is an exceedingly rare condition before the age of 8 months. Rickets and scorbutus are much more likely to be responsible for the signs and symptoms in the spine and extremities upon which a diagnosis of tuberculous arthritis is based. The prognosis in all forms of true surgical tuberculosis in infants is unfavorable. When suppuration occurs, the infant seldom survives.

Treatment of Surgical Tuberculosis.—Durante [6] reports a study of 540 lesions of surgical tuberculosis in which the abscesses or sinuses were treated by hypertonic salt solution. The lesions treated included the spine, hip, foot, shoulder, elbow and hand, as well as the ribs, sternum, tibia, sacrum, ilium, humerus and some of the bones of the skull. The usual methods for immobilizing affected joints were used, and every effort was made to improve the general condition of the patient, especially by giving milk for the sake of its calcium content. Heliotherapy was also employed. The hypertonic salt solutions used were three: 1. Calcium chlorid, gm. 2.5 in distilled water; gm. 100, with 5 to 10 drops of commercial liquor formaldehydi. 2. Sodium chlorid, gm. 2.5 with distilled water gm. 100, and 5 to 10 drops of commercial liquor formaldehydi. 3. Magnesium chlorid in the same strength as the other two salts. The technic consists of aspirating the abscess, washing it out and injecting from 10 to 40 c.c. of the hypertonic salt solution. The quantity injected usually is about one half that of the fluid aspirated. The injections were made once every four days. The calcium chlorid solution is usually used for the first two injections on account of its effect on the wall of the cavity, then the sodium chlorid solution is used. In case the tissues surrounding the abscess are in an especially poor condition, the magnesium chlorid solution is substituted, as it serves to activate the reparative processes of the tissues. The size of the cavity diminishes gradually, and finally it disappears. The action of the liquids is, first to cause a flow of lymph into the cavity for about two hours, followed by an outpouring of lymphocytes. In this way, the most active elements to combat bacteria and toxins are brought to the affected area. He reports that his results are excellent, although he does not give them in detail.

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5. Broca, A.: Nourrisson **11**:81-92 (March) 1923.
6. Durante, L.: Policlinico **30**:177, 1923.

Operations for the Relief of Pott's Paraplegia.—Fraser [7] has devised and performed in four cases an operation for the relief of paralysis secondary to tuberculous caries of the spine. He advocates the employment of this procedure in those cases in which a thorough trial of conservative measures has failed to relieve the paralysis and in which there seems to be real danger of a permanent degeneration of the spinal cord. The operative procedure consists of a division of the laminae above and below and at (?) the site of the lesion. No weakening of the column follows. Postoperative rest is essential, and in the cases in which this has been enforced, the results have been uniformly successful as regards recovery from the paralysis.

Sharpe [8] estimates that in between 5 and 8 per cent. of all cases of tuberculosis of the spine, we may expect to find signs of cord involvement; and that 90 per cent. of these cases may be completely or almost completely relieved by the conservative method of recumbency and hyperextension of the spine. If this type of treatment is to be followed, signs of improvement should be evident in from four to six months, and if not present by the tenth month, hope of recovery by conservative methods is not usually justifiable. Abscess is by far the most common cause of compression of the cord, with bony pressure second. Recumbency and hyperextension often relieve pressure from both these causes. In the approximate 10 per cent. of cases showing no improvement under these methods, continued pressure by bone, constrictions of the dura, pachymeningitis and obliterative arteritis may be held responsible. In this small percentage, laminectomy may be expected to relieve compression by bone detritus in the canal and constriction of the dura. Lesions within the dura are less favorable, since in the presence of active disease the dura should never be opened. Severe pachymeningitis or myelomalacia resulting from obliterative arteritis will be unrelieved by operation. Sharpe strongly condemns indiscriminate laminectomy, but urges prompt performance of it in the small proportion of cases in which the general condition of the patient warrants it and in which a thorough and continued employment of conservative methods has failed to influence the condition.

Tuberculous Tenosynovitis of the Head.—Kanavel [9] bases a discussion of this important condition on fourteen cases. From a pathologic point of view, he divides the disease into (1) an early stage and (2) a late stage. In the first or hygromatous stage, there is little or no change in the tendons themselves, but their sheaths are thickened and edematous and the tendons matted together. As the disease progresses,

7. Fraser, J.: Edinburgh M. J. **30**:385-392 (Sept.) 1923.
8. Sharpe, Norman: Am. J. Surg. **37**:142 (June) 1923.
9. Kanavel, A. B.: Surg., Gynec. & Obst. **37**:635 (Nov.) 1923.

the sheaths become obliterated by fibrous tissue, fluid is confined to definite areas and rice-bodies may be found in the fluid. Still later, the fluid is replaced by caseous material, the tendon sheath is invaded by granulation and fibrous tissue, fragmentation of the tendon itself occurs and several or all of the tendons are firmly bound together in a mass of fibrous tissue. In the final stage of uncomplicated disease, this fungous form is characterized by extensive formation of granulation tissue and caseous matter with or without rice-bodies. Kanavel holds that tuberculosis of the tendon sheath, if unaccompanied by active lesions elsewhere, may probably be more often cured than any other tuberculous process. The methods of cure comprise the conservative measures of removal of the rice bodies; injection of iodoform emulsion, and immobilization for a considerable period or by complete surgical removal of pathologic tissue. He emphasizes the importance of thoroughly removing this tuberculous material. The sugical treatment in his few cases has been more successful when the flexor tendons were involved than when the dorsal group was affected.

Heliotherapy.—Tisdall and Harris,[10] suspecting that the demonstrable value of heliotherapy in the treatment of tuberculosis of the bones and joints might be due to the action on the phosphate metabolism, as is apparently the case in rickets and tetany, have examined the blood of many patients subjected to this form of therapy. Their findings do not seem to justify this assumption. Frequently, the concentration of phosphorus in the blood of patients showing great improvement as a result of these exposures was below that of normal serum. The modus operandi of the osteogenic healing processes apparently stimulated by heliotherapy in bone and joint tuberculosis is still obscure.

POLIOMYELITIS AND OBSTETRIC PARALYSIS

Transplantation for Quadriceps Paralysis.—Colonna,[11] after a review of twenty-four personally observed end-results and the records of seventy-seven other cases, is convinced that satisfactory functional results may be expected from transplantation of the hamstrings in cases of quadriceps paralysis. He points out the importance of correcting any existing deformity before the transplantation is undertaken. If the biceps is strong, its transference yields better results than the inner or medial group. If the extensors of the hip are paralyzed, hamstring transplantation usually improves function so little as to be unwarranted.

Seiffert [12] reports twenty-nine cases of transplantation of the tendons about the knee. In twenty-six cases, the operation was undertaken

10. Tisdall, F. F., and Harris, R. I.: Canad. M. A. J. **13**:177-178 (March) 1923.
11. Colonna, P. C.: J. Bone & Joint Surg. **5**:472-479 (July) 1923.
12. Seiffert, Jr.: Beitr. z. klin. Chir. **129**:471-475, 1923.

because of paralysis of the quadriceps. He emphasizes the importance of transplanting only strong muscles, and attributes his one unsuccessful result to the weakness of the transferred muscle. In most of his cases, the biceps and one of the inner or medial tendons, usually the gracilis, were selected. The gracilis is chosen because it may be most easily reached. Its course is altered by shifting its pull far to the outer side and stitching its tendon to the periosteum of the patella, the vastus medialis or rectus, and to the tendon of the transplanted biceps, which reaches only to the upper border of the patella. The distal end of the gracilis is then reattached near its original insertion. In the author's opinion, the sartorius is rarely strong enough to assume the function of the quadriceps, and its transplantation should be restricted to those cases in which the hamstrings are paralyzed. He also believes that the semimembranosus should never be sacrificed since it is an important stabilizer of the knee and its transference may result in a genu recurvatum.

Foot Stability Following Poliomyelitis.—Caprioli [13] believes that the essential factor in valgus deformities following poliomyelitis is the paralysis of the anterior and posterior tibial muscles and a contraction of the calf group. In these cases, he considers that mutilating operations on the bones are neither necessary nor advisable. He is apparently satisfied with the functional results of lengthening the Achilles tendon, transplanting the tendon of the peroneus longus into the scaphoid at the insertion of the tibialis anticus and the peroneus brevis into the tendon of the tibialis posticus by the Biesalski-Mayer technic.

[ED. NOTE.—While we agree that in young children no mutilating bone operations should ever be performed and perhaps no bone operations of any kind before the age of 6 or 7, we do not consider the architectural readjustments of Hoke or the careful arthrodesis of Davis, Ryerson and others to be mutilating operations. We are fairly well convinced, moreover, that, except in the simplest types of faulty balance of the foot, the action of the transferred muscles has been difficult to predicate accurately, and their power in the new insertion hard to estimate in advance. We are inclined to believe that, in children over 6 years of age whose feet are unstable as a result of paralysis of certain muscle groups following poliomyelitis, only the most obviously indicated forms of tendon transplantation should be attempted unless some form of stabilizing, nonmutilating bone operation is performed, either previously or at the same time. The combination seems to us to offer much promise of permanent betterment. Ryerson [14] calls attention to the lack of successful results that have followed the various methods of tendon operations designed to stabilize paralytic feet. He believes that in cases

13. Caprioli, N.: Pediatria **31**:495-508 (May 1) 1923.
14. Ryerson, E. W.: J. Bone & Joint Surg. **5**:453 (July) 1923.

of calcaneovalgus, astragalectomy is the operation of choice and that tenodesis as advocated by Gallie is successful in many cases of drop foot. Davis of Philadelphia was one of the first American surgeons to recognize the importance of arthrodesis of the foot joints if permanent stability was to be obtained in these weak feet, which presented the disabling lateral deformities. In many of these cases, Ryerson advocates a procedure which he terms "triple arthrodesis." This consists of arthrodesing operations on the subastragaloid, mediotarsal and first and fifth tarsometatarsal joints. He describes the operation in detail, and his results are most satisfactory when combined with tendon transplantation following the stabilization.]

Campbell [15] suggests a rather ingenious operation for correcting drop foot. He removes the scaphoid and implants it in the os calcis just back of the tibia in order to block plantar flexion. He reports that the operation has been performed twenty-four times and that he considers the results satisfactory.

[ED. NOTE.—The operation may be found to have a place in certain cases of paralytic drop foot, but we need a more careful and complete study of the functional results followed for a period of years before we should consider it wise to replace older and well tried methods by this ingenious procedure.]

Aycock and Amoss [16] report a case of acute poliomyelitis, slowly spreading in its extent, and of the type of Landry's disease, which went on to involvement of the respiratory centers. The injection of hypertonic solutions and convalescent serum was carried on, and gradual improvement took place in a few weeks. No claim is made that the patient was benefited by the treatment, but the details of the method are shown and no harm was done by the procedure.

Aycock [17] has been doing further experimental work with hypertonic salt solution. It must be remembered that this experimental study adds a little to the hope of combating this disease. His few experiments are only enough to point out a way that may be followed by further experiments and observation. This small series of experiments seems to indicate that the use of intravenous hypertonic solution in conjunction with intraspinous convalescent serum has a favorable influence on the course of experimental poliomyelitis. This intravenous injection of sodium chlorid causes marked alterations in the circulation of fluid in the central nervous system. The best time for administration of the hypertonic solution and convalescent serum remains to be worked out.

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15. Campbell, W. C.: J. Bone & Joint Surg. **5**:815 (Oct.) 1923.

16. Aycock, W. L., and Amoss, H. L.: Treatment of Acute Poliomyelitis, J. A. M. A. **81**:474 (Aug. 11) 1923.

17. Aycock, W. L.: Bull. Johns Hopkins Hosp. **34**:361 (Nov.) 1923.

Daily repetition of the hypertonic sodium chlorid injection is associated with danger of respiratory failure.

Characteristic Spinal Fluid Findings in Acute Anterior Poliomyelitis.—The prevalence of poliomyelitis in Kansas this last summer has led Menninger [18] to make a very satisfactory summary of the diagnostic points in the cerebrospinal fluid. After going over the characteristics in various allied diseases, he reaches these conclusions: 1. Before meningeal invasion, the spinal fluid in poliomyelitis shows an increased amount, increased pressure, little or no globulin and no increased cell count. 2. After meningeal invasion, it is usually clear and rarely cloudy or yellow, and rarely presents the Froin syndrome. A fibrous web may form. The amount, the pressure and the globulin and albumin are increased. Alkaline copper solution is promptly reduced. The cell count is increased from ten to 2,500 cells per cubic millimeter. The first scale increase consists of polymorphonuclear leukocytes, but within from twelve to twenty-four hours after the invasion there are 80 per cent. mononuclear lymphocytes.

Diathermy in Acute Poliomyelitis.—Picard [19] calls attention to Wickmann's pathologic report concerning the important rôle which the edema of the meningeal structures plays in the pathologic and anatomic picture of poliomyelitis. Wickmann and Preiser believe that it is to a great extent due to this edema that the ganglion cells are affected and destroyed. The selection of certain parts of the spinal cord, especially the cervical and lumbar enlargement, may thus be explained on mechanical grounds. Preiser has advised performing a laminectomy in such cases, but few surgeons are willing to follow this advice owing to its considerable danger and uncertain therapeutic value. Picard has become convinced of the value of diathermy in reducing this edema. He uses two forms of application, the transverse for local lesions and the longitudinal for diffuse processes. He reports ten cases, seven of them of three or fours weeks' duration, two of seven weeks' and one of four and one-half months'. The author thinks that the immediate improvement setting in after a few treatments can be explained only by the beneficial influence of the diathermia on the pathologic processes going on in the meningeal structures. Picard recommends the method warmly, but with all reservation in regard to its mode of action, and confesses he has no scientific explanation of the apparently beneficial effect.

Bergamini [20] states that during the 1921 epidemic of poliomyelitis at Modena, Bordier's method of treatment was applied on an extensive scale, with encouraging results. This method comprises roentgen-ray

18. Menninger, W. C.: J. Kansas M. Soc. **23**:248-251 (Sept.) 1923.
19. Picard, H.: Deutsch. med. Wchnschr. **49**:13-15 (Jan. 5) 1923.
20. Bergamini, M.: Arch. de med. d. enf. **26**:521 (Sept.) 1923.

exposure and diathermy, applied to the paralyzed limb to stimulate the circulation and initiate repair by electrotherapy. Its purpose is also to combat the later atrophy of the paralyzed muscle. It has been established that a chilled normal muscle may simulate the reaction of degeneration, the same muscle when warm reacting normally. This combined treatment was employed as soon as the subacute phenomena had subsided. Sixteen cases are described in detail, the ages of the patients ranging from 5 months to 6 years. Four of the children were practically cured; eight were decidedly improved and two only moderately. The two others failed to complete the course. The benefit seemed in direct ratio to the promptness with which treatment was begun. The best effects were realized when the time that had elapsed since the onset of the paralysis was not more than twenty or thirty days. The roentgenotherapy consisted of three sittings on consecutive days each month, exposing the site of the spinal cord in the lumbar or cervical region, depending on whether the arms or legs were affected. The dose each time was about 6 X units. The diathermy was applied in four or five ten-minute sittings in each series, with a 500 or 600 milliampere current. A month generally sufficed to overcome the hypothermia and bring the limb to an approximately normal temperature. It was then ready for the third part of the treatment, namely, rhythmical galvanization, to the paralyzed muscles. Twenty daily sittings of from fifteen to twenty minutes were followed by thirty or forty days of rest. The current should not be over 3 or 4 milliamperes, but this electrotherapy should be kept up perseveringly for months and years if necessary. Considerable improvement had been obtained even when the reaction of degeneration was complete. This Bordier method conflicts with the old doctrine of immobilizing the limb, but Bergamini says that its success is unquestionable in poliomyelitis, whatever the patient's age, when applied before lesions have became irreparable.

[Ed. Note.—We believe that electrotherapy in some of its modalities may be of value, but it should not be employed to the exclusion of other methods whose value has been demonstrated.]

The organized work that has been carried on in Vermont for eight years under Dr. Lovett's [21] direction is an excellent example of the success of the special clinic. The following summary shows the broad scope of the work. 1. In the beginning, the supervision was purely the province of orthopedic surgery. 2. After-treatment by a trained field worker was added. 3. The scope of the field work was enlarged, and the worker investigated cases throughout the state needing treatment,

21. Lovett, R. W.: After-Care of Poliomyelitis in Vermont, J. A. M. A. **81**:921 (Sept. 15) 1923.

instead of waiting for the patients to be brought to the clinics. 4. A definite plan for handling operative cases was instituted. 5. A school for crippled children was founded. 6. A department of vocational training was established. It seems to the author that the number of disabilities from poliomyelitis has been greatly diminished, and the number of serious resulting deformities is considerably smaller than it would otherwise have been; that the patients have been, on the whole, appreciative and cooperative, and that many of them are now independent, useful citizens, capable of self-support, who otherwise would have been severely crippled if not quite helpless. But the continuance of these patients as active, useful individuals depends on their being carefully and persistently followed up. In other words, from being chiefly a surgical problem, the work has become largely a problem of supervision and after-care. Immediately after an epidemic and for two or three years more, the problem involves the principles of orthopedic surgery with definite requirements in the way of effective following up in the home. After three or four years, the surgical element becomes less insistent and the follow-up work more so.

OBSTETRIC PARALYSIS

Boorstein [22] has written a comprehensive article on the subject of obstetric paralysis, dealing with certain aspects of the problem. He calls attention to the fact that some of Taylor's deductions have been misunderstood; while Taylor himself has changed the time of operation. Taylor says that the small minority of patients that recover spontaneously are almost completely well at the end of three months. In the group of more serious cases, in which almost the entire musculature of the extremity is primarily paralyzed and the lower roots show no tendency to spontaneous recovery in the first few days, it is practically certain that a permanent lesion has occurred at least in the upper one or two roots, and early operation is indicated. In the still severer types, early operation is indicated without question if proper postural treatment can be carried out, and if, at the end of three months, improvement has been unsatisfactory, then, other things being equal, it is wise to explore the plexus. If, by chance, the plexus is found not so involved as to demand surgical treatment, the wound, which is practically only a skin incision, can be closed, and the risk to the child has been almost nothing. The advantage of this method is that, without material risk, one knows early in the case just what he is dealing with, and if surgical repair is necessary it is accomplished at a time when the chances of recovery are most favorable. Boorstein reports observations on fifty

22. Boorstein, S. W.: J. Bone & Joint Surg. **5**:778 (Oct.) 1923.

cases in which all kinds of treatment had been tried, and he is definitely in favor of the early operative treatment in those cases in which no improvement results in four months. This should be followed by proper brace treatment for about eight to nine months.

SYPHILIS

Dujardin [23] believes that many of the phenomena of syphilis are explainable as allergic reactions. In accordance with this conception, bone lesions are classified as secondary or early anallergic; tertiary or allergic parasyphilitic, and tardy anallergic. During the allergic phase, there is sensitization not only to spirachetal toxins, but also to other toxins such as tuberculin and even to harmless substances such as milk. Positive reactions by skin tests may be obtained with many substances and may prove misleading. He cites the case of a woman of 50 who had an osteitis of the tibia, the nature of which was demonstrated by the recovery of tubercle bacilli from a specimen of bone removed at operation. Later, she was found to have a positive Wassermann reaction, and the tibial lesion cleared up rapidly under syphilitic treatment. The author believes that the specific therapy caused a disappearance of the allergic condition and thus removed the foundation for the secondary tuberculous lesion, which vanished along with the syphilis.

Sutherland and Mitchell,[24] describing syphilitic bone lesions in children, state that they may be of two different types, depending chiefly on age. In the syphilitic fetus or new-born infant, the most common and characteristic lesion is an osteochondritis. In the first stage, the calcified zone between the epiphysis and the diaphysis becomes widened to a breadth of 2 mm. and appears as a white or pink line. In the second stage, the width is still further increased and necrosis of the bony trabeculae occurs owing to ingrowth of tongues of calcification. In the third stage, the periosteum and the perichondrium become thickened in the epiphyseal region in a manner resembling rickets. Separation of the epiphysis and pathologic fracture may result. In older children, ranging in age from 3 to 15 years, the bone process noted is more often a periosteitis, with or without a definite gummatous osteitis. This is usually most prominent in the tibia and results in deformities of the "saber tibia" type. The symptoms are usually rather indefinite and are often called growing pains or rheumatic pains. They are chiefly noted at night. The authors report a rapid disappearance of the symptoms following treatment by arsphenamin and potassium iodid.

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23. Dujardin, B.: Arch. franco-belges de chir. **26**:711 (Aug.) 1923.

24. Sutherland, G. F., and Mitchell, J. H.: Effects of Treatment on Bone Lesion in Congenital Syphilis, J. A. M. A. **81**:1752 (Nov. 24) 1923.

OSTEOMYELITIS

Lewis [25] contributes an excellent article on acute osteomyelitis, which well sets forth the general trend of modern surgical opinion on the treatment of this condition. In the main, he agrees with Starr and Speed that only rarely does the infection extend to the medullary cavity of the bone in the early stage. The path of least resistance seems to be toward the surface of the bone, with the formation of a subperiosteal abscess. Bone necrosis and the formation of sequestrums are variable factors. In a comparatively mild case, extensive sequestration may occur; while in another severe case, the sequestration may prove extremely small. He suggests that this may depend on thrombosis of larger or smaller branches of the nutrient vessels. As regards treatment, he favors the conservative operative procedure which is limited to drainage of the subperiosteal abscess when this is found or, in case this is absent, restricted opening of the cancellous tissue of metaphysis. Early diagnosis permitting prompt treatment is essential. He cites the figures of Rost, who studied the results of operation in 226 cases of acute osteomyelitis. In seventy cases, the medullary cavity was opened at operation, and of these patients, ten died, giving a mortality of 14 per cent. In 156 cases, the marrow space was not exposed, the operation being limited to free incision of the periosteum for drainage of a subperiosteal abscess. Of these patients, twelve died, giving a mortality of 7 per cent., and the development of pyemia was also of less frequent occurrence than in the former group. In the group of cases in which the marrow cavity was exposed and drained, suppurative arthritis and metastatic infection occurred twice as frequently as in the second group.

Peeremans [26] reports four cases of acute osteomyelitis of the ilium in children and calls attention to the difficulty of making a diagnosis during the early stage. The lesion with which it is most likely to be confused is septic arthritis of the hip; the localization of the pain, the spasm of the hip muscles, and the position of the limb which is held in flexion, abduction, and external rotation, all rendering differentiation from this condition very difficult. The following figures which he compiled from a survey of the cases of acute osteomyelitis in the Children's Hospital of Boston between the years 1913 and 1922 are of interest. These cases numbered 548 and formed about 5 per cent. of the total admissions. The femur was affected in 187, or 32.5 per cent.; the tibia in 94, or 17.1 per cent.; the humerus in 37, or 6.7 per cent. The jaw, radius, fibula and bones of the tarsus came next in order. In this group, there were only seven cases of osteomyelitis of the ilium; whereas Michelson reported 137 cases, or 13 per cent., in a hospital for adults.

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25. Lewis, Dean: South. M. J. **16**:1861 (Nov.) 1923.
26. Peeremans, G.: Arch. franco-belges de chir., October, 1923, p. 970.

Vaccine Therapy.—Grisanti [27] reports his observations in twelve cases of acute osteomyelitis in children and draws the following conclusions: 1. The results of treatment depend on prompt surgical intervention, associated with immediate vaccine therapy. 2. Vaccines have an undoubted effect in hastening the cure of the local condition and also in improving the general condition. 3. Autogenous and stock vaccines act equally well. The important rule is to use maximum doses in the briefest possible time and not to stop the treatment after the first injection, as various observers have been accustomed to do.

Osteomyelitis Variolosa.—Brown and Brown,[28] writing on the osteomyelitis of smallpox, state that bone complications which give rise to symptoms are very rare in that disease. Reports of lesions demonstrated by the study of pathologic specimens and of bone deformities developing as late sequelae are, on the other hand, fairly numerous. The authors report two cases, one of which is of special interest because of the report of multiple lesions found at necropsy. The authors conclude that at least two distinct types of osteomyelitis may occur as complications in smallpox. The first is the ordinary pyogenic metastatic osteomyelitis, which develops here just as in the case of other infectious diseases. The second is a distinct form of necrosing, nonsuppurating osteomyelitis, probably due to the specific virus of smallpox. It frequently involves the diaphyseal ends of the long bones, destroying the epiphyseal growth disk and causing late deformities. The specific form of variolar osteomyelitis occurs most commonly in children. It is not recognized during the acute phase of the disease, and the deformities are often overlooked because their evolution is gradual and the patient leaves the care of the physician before they have fully developed.

ARTHRITIS

Pathology.—Timbrell Fisher [29] reports his investigations on the nature of the pathologic changes occurring in so-called rheumatoid and osteo-arthritis. He feels that the lack of knowledge is due to ignorance of the physiology of articulations, and variance of opinion as to structure of cartilage, synovial membrane and the pathologic changes. He disagrees with the present confusing nomenclature. His studies led him to two types and a mixed type: Type I. Chronic arthritis in which the disease commences in the articular cartilage (osteo-arthritis). He describes the changes as beginning in the central area of the cartilage, first in color, then in fibrillation of the cartilage and later in softening

27. Grisanti, S.: Pediatria **31**:649-671 (June 15) 1923.

28. Brown, W. L., and Brown, C. P.: Osteomyelitis Variolosa, J. A. M. A. **81**:1414 (Oct. 27) 1923.

29. Fisher, A. G. Timbrell: Brit. M. J. **2**:102 (July 21) 1923.

of the mucinous elements, which he feels is due to a substance contained in the synovial fluid. The behavior of the cells is quite different from what would be expected in a degenerative process. The cells are not devitalized, but groups actively proliferate as if from some irritative process. Lipping occurs coincidently. He feels that the term hypertrophic (Goldthwait) is a misnomer, but to call the process degeneration (Nichols and Richardson) is absurd. As the cartilage disappears, the subjacent bone becomes sclerosed. Later, the synovia becomes villous. The hyperplasia of all elements strongly negatives the theory of a degenerative disease. That the synovial fluid is not lacking in nutritive quality is shown by the fact that bits of cartilage break off and actually grow in the fluid. Later stages show a sclerosis of the membrane and blood vessels. This, however, is not etiologic. The changes are inflammatory rather than degenerative, and he concludes that osteo-arthritis is not a disease but a series of pathologic and physiologic changes in a joint subject to prolonged and repeated injury, either mechanical or toxic, of moderate intensity. Type 2. Chronic arthritis in which the disease commences in the synovial membrane (rheumatoid arthritis). In the main, the author agrees with Nichols and Richardson. He dislikes the term "atrophic," as it is confusing, the disease in his opinion being markedly inflammatory in nature and the atrophy explained on the ground of nonuse. Degenerative and proliferative changes occur together in the articular cartilage, which is invaded by a pannus of granulation tissue, in vascular connective tissue. Fibrillation of the cartilage occurs. He explains the central cartilage, degeneration and lateral proliferation on the ground of nutrition and blood supply. He suggests the following classification, based on the site of the origin: Chronic arthritis: 1. Synovial type beginning and remaining in the synovial membrane; invasion of the cartilage and bone secondarily with all gradations from acute to chronic (rheumatoid arthritis). 2. Chrondo-osseous: Beginning and remaining marked in the articular end of the bone; synovial membrane changes later (osteo-arthritis). 3. Mixed type. The studies of Poynton and Paine, he believes, point to an infective origin.

A Bacteriologic Study of the Intestine in Connection with Arthritis.—Persson,[30] in reporting 2,973 cases studied over the years 1910 to 1922, in patients from 23 to 85 years of age, 87 per cent. over 35, at Mt. Clemens, classifies arthritis into Types 1 and 2. Type 1 is characterized by proliferation of synovial and lymph marrow, causing degeneration of bone and cartilage. Type 2 is characterized as degeneration of the synovial and lymph, causing hypertrophy of bone and cartilage. Type 1 includes definite infections, as tuberculosis and syphilis. Type 2 is

30. Persson, G. A.: New York M. J. **118**:363 (Sept. 19) 1923.

sharply differentiated from Type 1 and includes arthritis deformans; osteo-arthritis and degenerative arthritis, and hypertrophic and senile arthritis. He believes in an infective cause and divides the infections into an upper and lower zone: the upper, the mouth and nose; the lower, the intestines and appendages. The majority of his cases fall in the lower zone. He believes in selective peculiarity of the bacteria. By opsonic tests with strains of bacteria of selective location, he locates the infected area. An antigen is prepared and the patient immunized. He reports good results.

Synovectomy in Chronic Infectious Arthritis.—Jones [31] reports the synovectomy of the knee joint in chronic arthritis by the split patellar route. Special emphasis is laid on very early motion and careful selection of cases, he having operated in twelve cases out of 300 seen in the last ten years.

[ED. NOTE.—This conforms with previous work reported by Swett in a previous *Report of Progress.* It would seem fair to call attention to the fact that this procedure was used and reported by Goldthwait in 1900.]

Present Conception of Arthritis.—Cuneo,[32] in discussing the theories of arthritis, reports interesting alterations in the organic chemistry in relation to the law of equilibrium between nitrogen and calories. He states that his experiments demonstrate that arthritic disease not only has a different pathologic origin but also requires a different biochemical alimentary therapy. By regulating alimentation, he secures perfect nitrogen equilibrium, as in the normal person, in whom pathologic products do not occur. He promises more facts about these endogenous intoxications later.

[ED. NOTE.—No one so far knows exactly what occurs in the intestines that causes intoxication. Many students of arthritis believe in the intestinal origin of much of the joint disease.]

Further Observations on Arthritis and Rheumatoid Conditions.—Pemberton [33] has continued his chemical studies of chronic arthritis without final conclusions. He feels that the blood flow in arthritis in the capillary circulation may be below normal, one or more undetermined factors interfering with utilization of oxygen or its removal, the most likely explanation being disturbance of the capillary control. The result is comparable to some effects produced by altitudes reported by Barcroft. He feels that, at all events, one seems to be dealing with

31. Jones, Ellis: Synovectomy of Knee Joint in Chronic Arthritis, J. A. M. A. **81**:1579 (Nov. 10) 1923.

32. Cuneo, G.: Riforma med. **39**:535-538 (June 4) 1923.

33. Pemberton, Ralph: Am. J. M. Sc. **166**:833 (Dec.) 1923.

a true chemical process in which the radicals of carbon dioxid and phosphorus pentoxid play an important rôle in bony metabolism. In line with this is the fact that measures that have proved of benefit in arthritis seem to depend on an increased local or systematic metabolism or blood flow.

METASTATIC TUMORS OF BONE

Joll [34] shows that a knowledge of bone metastases, their method of production, the types of neoplasms which give rise to them and their special clinical manifestations are essential not only in the study of pathology but also in the practice of surgery. Of 144 cases of malignant disease, fifty-three showed bone metastases. In thirty-four of these cases, the primary tumor was situated in the breast. The vertebrae were involved in 21.6 per cent. of the cases; the ribs in 20.4 per cent.; the sternum in 14.7; the femur in 14.7; the skull in 10.2; the humerus in 7.9; the pelvis in 4.5; the tibia in 2.2; the mandible in 1.1; the scapula in 1, and the clavicle in 1.1.

[ED. NOTE.—This is an exceedingly valuable paper, emphasizing the need of more than a local examination in cases of malignancy. It is interesting to note that 64.2 per cent. of metastatic tumors were primary in the breast, and that metastases to the spine and ribs were prevalent.]

LOW BACK AND SCIATIC PAIN

Graves,[35] in an article on the relation of backache to gynecology, says that in cases of simple retroversion without prolapse and with the single symptom of low backache, the patient is referred for expert orthopedic diagnosis and treatment. This is because retroversion does not always cause symptoms. If, however, there is associated with the retroversion prolapse and genital relaxation, a reconstructive operation is advised even if orthopedic errors are evident. The backache of patients with genital prolapse is for the most part referable to the tired condition of the patient. It may occur in patients with normal backs or it may represent the accentuation of strains due to orthopedic errors.

Willis,[36] in an anthropologic study of mammalian vertebral columns, shows that the human column has a relatively high degree (95.8 per cent.) of stability of the number of thoracic and lumbar vertebrae, the modal number being seventeen. The lumbar portion of the column adjacent to the sacrum presents certain morphologic defects described as bifid and separate neural arches, the latter occurring three times as often as the former. Both defects result in weakness of the column; the

34. Joll, C. A.: Brit. J. Surg. **11**:38 (July) 1923.
35. Graves, W. P.: Boston M. & S. J. **189**:1057 (Dec. 27) 1923.
36. Willis, T. A.: Am. J. of Anat. **32**:95 (July) 1923.

bifid arch by impairing ligamentous attachments; the separate arch through loss of bony anchorage of the column to its base. Either defect may not be evident until severe stress or trauma. The bifid arch results from arrest of development before fusion of the laminae takes place; the separate arch, from irregular ossification with interruption of bony continuity. Muscular strains, lumbosacral sprains and spondylolisthesis often accompany these developmental defects, but may also be dependent on malformations of the articular processes.

STATICS AND FOOT STRAIN

Some Confessions of an Internist Regarding Body Mechanics.—Lee [37] says that his work at Harvard showed him, in a general way, that the most important problem was the creation of a standard for the healthy members of the group being examined. He found that positive organic disease was relatively small, under 5 per cent. However, it was perfectly evident that although 95 per cent. of the college population were organically sound, in that no organic defects were found, nevertheless 95 per cent. were not entirely robust, healthy individuals. Attention was therefore brought to the various physiologic systems of the body for the purpose of attempting to evaluate the well-being of the individual as a whole. Among these systems, the question of body mechanics arose. Experience has shown that functional disturbances of other systems, for example, vasomotor instability or even nervous instability, tended to be associated with poor function in body mechanics. In checking up cases of albuminuria, a considerable portion of them had been previously classified in the very bad body mechanics group. Lee ends his article by saying that it must be emphasized that important though body mechanics is, it is only one of the systems of the human body, and any evaluation that confines itself to one system will leave out of consideration many factors that may be of paramount importance.

A New Chart for the Standardization of Body Mechanics.[38]—The Department of Hygiene at Harvard, realizing that the original chart used for standardizing body mechanics, although on the whole very satisfactory, had several very definite faults, has had a new chart prepared. The new chart is based on a study of individuals who belong to the narrow, thin type. The justification for making a new chart is that it is becoming clearer with the accumulating evidence that the muscular compensation of defects in body mechanics, which is so common and easy in youth, not infrequently fails when active physical exercise is given up for a sedentary life.

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37. Lee, Roger I.: J. Bone & Joint Surg. **5**:747 (Oct.) 1923.
38. Lee, R. I., and Brown, L. T.: Bone & Joint Surg. **5**:753 (Oct.) 1923.

A New Method of Recording Posture.—This is a very ingenious method of taking silhouettes [39] by the use of a special camera which takes pictures on sensitized paper. As many as twenty-four pictures can be taken on the same paper if the images are not too large; four of a very good size can be taken on 5 by 7 paper. The expense of the pictures is about one cent or less, depending on the size. This machine has been used at Harvard and at many of the schools around Boston with much satisfaction, as it gives a graphic record that is self-explanatory to the students and can be kept from year to year.

Ptosis of the Heart and Diaphragm. Important Points for Determination in the Chronic Patient.—This article [40] is written to show that there are marked differences in the shape and position of the diaphragm and the heart as found in the so-called normal seen in the textbook, and that found in the patients seen in a large clinic for chronic disease. In order to demonstrate this, it is important to have roentgenographic and fluoroscopic studies of the heart and diaphragm in both the lying and the standing positions. The special symptoms associated with the different positions are not described, but it is hoped that the profession will realize that the conditions shown in the many roentgen rays do exist, and that once this is admitted, an entirely different examination be given, and such mechanical findings cannot fail to suggest reasons for symptoms with the natural lines for relief.

RACHITIS, OSTEITIS FIBROSA, COXA PLANA

Hess and Matzner,[41] studying the phosphorus and calcium balance of parturient women and their offspring in an endeavor to determine whether prenatal influences of any kind may have an effect in the production of this disease, found that the inorganic phosphate of the blood of the mother is almost invariably lower than that of her infant at birth, as is also the calcium, only to a lesser extent. The inorganic phosphate of the new-born is generally lower than that of infants 1 month of age or older. However, even when the percentage was within the rachitic range, no clinical or roentgenologic evidence of rachitis could be found. No relationship was found between the percentage of inorganic phosphate in the blood of the new-born and the occurrence of rachitis during the first year of life.

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39. Fradd, N. W.: J. Bone & Joint Surg. **5**:757 (Oct.) 1923.

40. Goldthwait, J. E.: Boston M. & S. J. **189**:581 (Oct. 25) 1923.

41. Hess, A. F., and Matzner, M. J.: Rickets in Relation to Inorganic Phosphate and Calcium in Maternal and Fetal Blood, Am. J. Dis. Child. **26**:285 (Sept.) 1923.

Hess and his co-workers [42] report, after extended investigation, that rats may fail to develop rachitis on the standard "rickets producing dietaries," whether low in phosphates or in calcium. The refractory state was found to be due to the liberality of the diet during the preexperimental period, the first four weeks of life. It was overcome and susceptibility to rickets induced by feeding mother and young a restricted dietary during the suckling period. Resistance was also broken down by having the mother suckle young in addition to her own litter. This probably resulted in an inability on the part of the young to store a reserve of the antirachitic factor.

Hensch and Kramer [43] have been trying to find a simple and reliable method to detect rachitis at a time before the appearance of the well-known clinical symptoms, such as craniotabes. The authors have examined the increased excretion of phosphates in the urine and the content of diastase, which is much raised in rachitic children. They have found that (1) the content of phosphate and diastase is strikingly parallel, and (2) in rachitic infants, the content is at least double, frequently eight or ten times that of normal infants. Certain complications, such as pyelitis or fever, must be excluded. The authors found out that (1) at least two thirds of all patients coming to the examination with undoubted signs of rachitis have positive findings in the urine; (2) occasionally, it is possible to predict rachitis by these metabolic disturbances before the clinical signs have become manifest, and (3) the difficult differential diagnosis between rachitic craniotabes and the congenital atypical soft skull could be made evident by the study of the phosphate and diastase content of the urine.

Metabolism studies have shown that infants with active rickets fail to retain calcium and phosphorus, although an adequate amount is present in the diet. Ultraviolet radiation causes large amounts of these elements to be retained in the body. Increased amounts of calcium and phosphorus are found in the urine after ultraviolet radiation, indicating an increased absorption from the intestine. It is argued by Orr and others [44] that defective absorption from the intestine in active rickets is the cause of the low concentrations of calcium and phosphorus in the serum, and is the ultimate cause of the defective calcification of the bones.

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42. Hess, A. F.; Weinstock, M., and Tolstoi, E.: J. Biol. Chem. **57**:731-740 (Oct.) 1923.

43. Hensch and Kramer: Klin. Wchnschr. **48**:2205 (Nov. 26) 1923.

44. Orr, W. J.; Holt, L. E., Jr.; Wilkins, L., and Boone, F. H.: Calcium and Phosphorus Metabolism in Rickets, With Special Reference to Ultra Violet Ray Therapy, Am. J. Dis. Child. **26**:362 (Oct.) 1923.

The evidence presented by Hess and others [45] is as follows: In moderate rickets, the phosphorus or calcium or both may be moderately lowered. In severe rickets, the phosphorus is markedly reduced, even in children exclusively breast fed, while the calcium may or may not be lowered. In approximately 40 per cent. of the cases of tetany studied severe rickets was present. In rickets complicated by tetany, the calcium is considerably reduced. The phosphorus may or may not be reduced. Under treatment, in the severe cases of rickets complicated by tetany, the phosphorus content at first shows a tendency to decrease or to remain stationary. These studies demonstrate that there is a more or less definitely different blood picture in rickets and in rickets associated with tetany, but the authors feel that these represent two phases of the same disorder rather than two distinct types, and that the blood picture may be affected by extraneous factors and may vary according to the activity or healing of the process.

Paton and Watson,[46] although not willing to support the theory that rickets is an infectious disease, agree to the possibility that a particular condition of the intestinal flora which might be propagated by fecal infection may so modify the absorption of calcium and phosphorus as to lead to rachitic changes.

Schultzer and Sonne,[47] in a preliminary report from the Finsen Institute, reach the following conclusions: Light treatment within the entire spectrum causes improvement in rachitis. If the ultraviolet rays are cut out by means of a screen, no effect is obtained; i. e., there is no improvement. The extreme ultraviolet rays may be eliminated without altering the beneficial effects. In rickets, the quartz light is more effective than sunlight or carbon arc light. In tuberculosis, sunlight and carbon arc light are more effective than quartz light. The effective part of the spectrum is not as yet known: it may be the luminous rays.

Kneschke [48] has studied the blood calcium in fourteen rachitic children who were treated with artificial sunlight. In most cases, twenty exposures were given, and at every third or sixth exposure blood was taken. In ten cases, a normal amount of blood calcium was found at the end of the treatment; whereas, before the treatment, the amount was abnormally high. A clinical cure or marked improvement was seen,

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45. Hess, J. H.; Calvin, J. K.; Wang, C. C., and Felcher, A.: Calcium and Phosphorus Determinations in Blood Plasma in Rickets and Tetany, Am. J. Dis. Child. **26**:271 (Sept.) 1923.

46. Paton, D. N., and Watson, A.: Brit. J. Exper. Path. **4**:177-195 (Aug.) 1923.

47. Schultzer, P., and Sonne, C.: Hospitalstidende **66**:541-552 (Aug. 1) 1923.

48. Kneschke, W.: Klin. Wchnschr. **2**:1935 (Oct. 15) 1923.

being indicated by the disappearance of the craniotabes, and improvement of the static function and of the general condition. The author thinks that it is not the quality of the light, but the proper dosage, which determines the result.

At a meeting of the Northwestern Surgeons in Greifswald, Germany,[49] the question of the correction of rachitic curved legs was discussed. Ringel operates only when the rachitic process has come to a standstill, and when the deformity is so great that the neighboring joints are liable to be damaged. For the tibia, he uses the complete resection of the curved part, leaving the periosteum carefully in close touch with the adjoining soft tissues. Ranke reports 109 cases in which excellent results have been obtained by manual osteoclasis or by the use of Still's osteoclast. He prefers the operation during the florid stage. Deutschlaender points out that the choice of the kind of operation with or without open incision depends on the stage of the rachitic process. In marked curves, he uses Ringel's complete resection, without replacing bony material.

Orth[50] recommends resection of the curved part of the tibia in severe rachitic bowlegs. He emphasizes the speed with which bony tissue grows out after excision of the bone within the carefully sutured periosteal tube. After only eight weeks, the children were again on their feet. The cosmetic result is superior to that seen in simple osteotomy.

[ED. NOTE.—We feel that the procedure advocated by Ringel is extremely radical, and in our experience simpler operations have resulted in satisfactory correction of the deformity.]

COXA PLANA

Nussbaum[51] describes pathology and therapy or osteochondritis coxae juvenilis. The symptoms resemble those of coxa vara and differentiation may be impossible without the roentgen-ray picture. Free flexion with more or less limitation of abduction and rotation generally allows some differentiation from tuberculous hip disease. Nussbaum calls attention to Axhausen's histologic studies showing complete necrosis of the spongiosa of the head with preservation of the articular cartilage. The same results have been obtained in the experiment by Nussbaum through severing of the vessels furnishing the nutrition of the head of the femur. These clinical and experimental studies prove that the nutrition of the articular cartilage is provided by fluid.

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49. Stajskal, K.: Zentralbl. f. Chir. **50**:1523 (Oct. 6) 1923.
50. Orth, O.: Zentralbl. f. Chir. **50**:989 (June 23) 1923.
51. Nussbaum, A.: Deutsch. med. Wchnschr. **49**:849 (June 29) 1923.

Jansen [52] describes thirty-three cases of flattened hip socket, and explains the relation of the flattened socket as a cause of the change of angle in the neck by changing the normal line of stress. He describes the stress to which the hip joint is subjected and the effect of growth on the form of the bones. In children who have been enfeebled by injurious agents, the functional stresses of muscle action and body weight may retard the growth of bone and alter the shape of bones once formed. This occurs earliest and to the greatest degree at the times of and in areas of rapid growth. It is impossible to state his hypotheses in a few words and the article must be read to be appreciated.

A monograph by Dawson and Struthers [53] is based on extended study in the research laboratory of the Royal College of Physicians of Edinburgh. An endeavor is made to describe the essential histologic features in a case of generalized osteitis fibrosa and to indicate the conceptions underlying the pathologic process involved in bone dystrophies. The view put forward relates osteitis fibrosa to an initial disturbance of the controlling activity of the bone cell over its calcium metabolism, an activity which is normally regulated by a hormone from the parathyroid glands. The process of decalcification is thus reduced to a defective functioning of the bone cell, following damage by an agent circulating in the blood or deranged hormone control. The damage to the bone cell may be caused by any one of the factors outlined above, especially toxins resulting from faulty tissue metabolism and those elaborated in the intestinal tract. The automatic regulation of the supply of hormones, or in other words the call of the damaged bone cell for an increased hormone, leads to hyperactivity of the parathyroid gland, a hyperactivity which results in hyperplasia and in a possible perversion of the hormone; for, in spite of its hyperplasia, the protective regulation of the activity of the bone cell is insufficient.

Malacia of the Carpal Semilunar Bone.—Sonntag [54] describes the so-called malacia of the carpal semilunar bone, basing his discussion on personal observation of twelve cases. Eight of the patients were men engaged in hard labor. The pathologic changes consist in necrosis of the bone and infiltration of the neighboring tissues, in a way resembling the changes seen in Köhler's disease of the head of the second metatarsal bone. Traumatism seems to play a definite rôle so far as it interferes with nutrition, but Sonntag ascribes an important part to a constitutional predisposition, which also explains its rare occurrence. In the post-traumatic cases, three stages may be distinguished: (1) a stage of primary irritation; (2) a stage of quiescence lasting from a few weeks

52. Jansen, Murk: J. Bone & Joint Surg. **5**:528 (July) 1923.

53. Dawson, J. W., and Struthers, J. W.: Edinburgh M. J. **30**:421-564 (Oct.) 1923.

54. Sonntag: Fortschr. a. d. Geb. d. Röntgenstrahlen **30**: No. 5-6, 1923.

to months, and (3) the permanent, chronic stage attended by periods of acute exacerbation. The symptoms are pain, tenderness, local swelling, especially on the dorsal side, limitation of motion and, less frequently, prominence of the affected bone, crepitus and shortening of the carpus. The roentgenogram is typical in advanced cases, but in the early stage is negative. The semilunar bone is flattened in its longitudinal axis and its structure is indistinct with thickened and thinned portions. The treatment should be conservative, consisting at first of rest, to be followed later by baking, diathermy, massage and exercise. General constitutional care is advisable. Only in persistent cases is operative interference required.

KÖHLER'S DISEASE OF THE METATARSAL

Lewin [55] discusses this condition under the title of juvenile deforming metatarsaphalangeal osteochondritis. He has been able to collect sixty-three cases from the literature, and has followed two personal cases with serial roentgenograms over a considerable period. The changes in the bone closely resemble those seen in the Calvé-Legg, Osgood-Schlatter and similar diseases. The three etiologic factors are trauma, circulatory disturbance and infection. The condition may be mistaken for ordinary metatarsalgia, but its occurrence in the childhood and adolescent period should be suggestive. The symptoms are local pain, tenderness, swelling and limitation of motion. The roentgenologic changes are flattening of the metatarsal head, broadening of the neck and distal portion of the shaft, irregularity of the epiphyseal line, widening of the metatarsophalangeal joint space, diminished cupping of the articular surface of the proximal phalanx and, occasionally, the appearance of an incomplete fracture without displacement of the metatarsal head.

Several writers in the German literature have recently discussed Köhler's disease. Kappis [56] insists that the disease is a result of fracture of the head of the second metatarsal bone, from violent trauma. Schreuder [57] insists that it is the result of repeated and long continued traumatism, such as that caused by wearing high heeled shoes, especially true when growing individuals have worn such shoes. Cahen believes that trauma is secondary; that there is no fracture, but that an embolism in the metatarsal head leads to necrosis and softening of the spongy

55. Lewin, Philip: Juvenile Deforming Metatarsophalangeal Osteochondritis, Freiberg's Infraction of Metatarsal Head, J. A. M. A. **81**:189 (July 21) 1923.
56. Kappis, M.: Beitr. z. klin. Chir. **129**:61, 1923.
57. Schreuder, O.: Deutsch. Ztschr. f. Chir. **178**:145-159, 1923.

bone. Axhausen [58] has previously advanced this theory in explanation of the condition, and recently has reiterated it. Klett [59] does not believe that trauma alone can cause Köhler's disease. He thinks there is some etiologic factor similar to that of osteitis fibrosa, perhaps some disturbance of internal secretion. Heitzmann [60] and Engel believe, with Axhausen, in a primary necrosis caused by disturbance of circulation. Lehmann [61] believes Köhler's disease is similar to Legg-Perthes' disease and Osgood-Schlatter disease; some systematic disturbance which acts unfavorably on subchondral ossification.

LEONTIASIS OSSEA

Knaggs,[62] in a well-illustrated article, gives a very complete description of this condition. He distinguishes two general types. The first is a chronic periosteitis which spreads slowly from one bone of the face to another. It usually begins in the region of the nasal fossae or accessory sinuses. It appears to be the result of bacterial infection, although as yet no definite bacteriologic evidence of this has been forthcoming. The second type is a diffuse osteitis of the bones of the face and skull with changes in the osseous tissue similar to those of osteitis fibrosa. It usually appears in the first or second decade and seems to be of toxic origin.

Longitudinal Overgrowth of Long Bones.—Speed [63] reports three cases of overgrowth of long bones, the etiologic factor in two cases being an acute infectious process in childhood, and in the third a traumatic strain of the epiphyseal junction without actual displacement. He concludes that overgrowth may result from inflammatory disease of bone, not necessarily involving the epiphyseal area, or that it may follow epiphyseal displacement of even slight degree. There is no means of predicting in a given case whether such conditions will produce any disturbance of growth or, in case this does ensue, whether the result will be lengthening or shortening of the affected limb. Active use and weight-bearing should be encouraged in all cases at the earliest possible moment.

Interpretation of Sulci on Certain Bones.—Henry [64] calls attention to inaccuracies in the interpretation of the function of certain osseous

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58. Axhausen, G.: Med. Klin. **19**:561 (April 29) 1923; Arch. f. klin. Chir. **124**:511, 1923.
59. Klett, Walter: Fortschr. a. d. Geb. d. Röntgenstrahlen **30**:501, 1923.
60. Heitzmann and Engel: Klin. Wchnschr. **2**:397 (Feb. 26) 1923; ibid. **2**:444 (March 5) 1923.
61. Lehmann.: München med. Wchnschr., No. 2, p. 170, 1923.
62. Knaggs, R. L.: Brit. J. Surg. **11**:347 (Oct.) 1923.
63. Speed, Kellogg: Surg., Gynec. & Obst. **36**:787 (June) 1923.
64. Henry, A. K.: Irish J. M. Sc., October, 1923, p. 295.

grooves. Thus, the sulci on the anterior surface of the sacrum are always described as grooves for the conveyance of the sacral nerve roots, when it is well known that the pyramidalis muscle intervenes between these nerves and the bone. The case is similar in regard to the grooves on the first rib, which are usually described as for the subclavian vessels. Recently, Wood and Stiles have claimed that the most posterior of these grooves is made by the first dorsal nerve. This point is important, as it is of clinical significance in explaining some of the cases of brachial neuritis. Henry's investigations do not confirm this view. Indeed, in some dissections, it was found that the groove was not occupied by any structure. He advances the opinion that the sulci are constituted by raised borders, which serve as points of attachment for muscles. According to this view, the sulcus is not a defect in the bone, but is similar to a street whose existence depends on the structures which border it, rather than the traffic which it transmits.

Ossification in Scars.—Volkmann [65] reports six cases of ossification in scars of the abdominal wall. The condition is comparatively rare. The author has been able to find only twenty-eight cases in the literature. The most frequent site is the median line above the umbilicus, far removed from any bony tissue. The time required for osseous development was from five weeks to five years. For ossification to occur in soft tissues, three conditions must present: an adequate supply of free calcium, a hematoma and connective tissue of embryonic type. Even then, a stimulating influence is necessary to start the ossifying process, and this may be supplied by operative trauma, by an infection, however mild, or by a mechanical strain. The importance of the last mentioned factor seems quite evident when it is noted that, in many of the reported cases, there has been pneumonia or asthma, indicating the probability of severe mechanical strain of the sutured incision. The type of ossification varies, sometimes being periosteal and at others enchondral. Boss attributes considerable importance to an atavistic influence and calls attention to the fact that the inscriptiones tentinae of the recti muscles have been regarded as rudimentary ribs. The best treatment is radical excision, which, however, should not be performed too early.

Thrombo-Angiitis Obliterans.—Rabinowitz [66] reports the results of his investigations of the etiology of this condition. While more work remains to be done, the evidence thus far obtained points to the infectious origin of the disease. He has been able to isolate a specific organism from the blood stream. By the inoculation of this bacillus in rabbits, it was possible to produce the same lesions in the ears and feet

65. Volkmann, J.: Med. Klin. **19**:1019 (July 22) 1923.
66. Rabinowitz, H. M.: Surg., Gynec. & Obst. **37**:353 (Sept.) 1923.

as were present in the calf of the leg of the human patient. These lesions, in both their gross and their microscopic pathology, were similar to those seen in thrombo-angiitis obliterans. The bacillus was isolated both from the blood of the locally affected portion and from the blood stream. It was distinctly hemoglobinophilic. In three rabbits, lesions on the plantar surfaces and toes only appeared five weeks after the inoculation. This showed conclusively that the organism enters into the general blood stream and that it possesses a specific tissue predilection. Hemolized blood is necessary for the isolation and cultivation of the bacillus outside the body.

Sympathectomy.—Kümmel [67] reports his experience with the operation of sympathectomy in thirty-four cases. The adventitia was removed over a distance of from 8 to 10 cm. in the case of the femoral artery and of from 6 to 8 cm. in the case of the brachial artery. Immediately after removal, the artery contracts very markedly, except in cases of advanced arteriosclerosis, and the bleeding from the walls of the artery ceases. Kümmel has never seen any harm result. About five hours after the operation, the preliminary anemia caused by the arterial clonus changes to a marked hyperemia, improving also the capillary stream, as disclosed by the capillary microscope. In most cases, the pain was much relieved, sometimes even in the opposite limb where no operation had been performed. Among the conditions treated were cases of Reynaud's disease, trophoneurosis of the amputation stump, diabetic gangrene, severe ulcus cruris, congelation, elephantiasis, tabes with lancinating pain, dermatitis symmetrica dysmenorrhoica, psoriasis and chronic eczema. In many cases, cure or marked improvement has been noted, though many are still too recent to warrant definite conclusions. Generally, it may be stated that the older the affection, the less is the chance of cure.

Kreuter [68] issues a note of warning to those enthusiasts who regard the operation of sympathectomy as entirely harmless. He reports a case of arteriosclerotic gangrene in which, ten days after operation, and despite an aseptic course, the femoral artery began to leak. A rapid extension of the gangrene followed, resulting in death. Kreuter recommends, in such cases, the partial removal of the adventitia, taking away only one half of the circumference. He further suggests that, in many of the cases in which improvement has been obtained, much of this result may be attributed to the enforced period of recumbency. He has seen recurrence after weeks and months in cases in which the patients had been on their feet again.

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67. Kümmel, H., Jr.: Zentralbl. f. Chir. **50**:1434 (Sept. 22) 1923.
68. Kreuter: Zentralbl. f. Chir. **50**:1685 (Nov. 17) 1923.

BONE AND JOINT SURGERY

Arthroplasty.—An interesting discussion on arthroplasty took place at the International Congress of Surgery in London.[69] The subject was formally presented in papers by Hey Groves, Putti, MacAusland and others. The report of the general discussion of the subject of arthroplasty which followed the papers is abstracted in the *British Medical Journal.* From this report, one is led to conclude that, in the minds of those who took part in the discussion, there is a feeling that arthroplasty is not as yet a surgical procedure from which standard results may be expected. Successes so far obtained depended on a careful selection of cases, age, good musculature and a disposition on the patient's part to cooperate with the surgeon in spite of pain. The patient's occupation must be considered, also his financial ability to withstand a long period of hospital care and treatment. There was a unanimous objection to performing arthroplasty in cases in which ankylosis had followed tuberculous infection. Bony ankylosis was considered a more favorable condition for operation than fibrous ankylosis. Ankylosis due to traumatic arthritis or acute infections, it was agreed, gave the best promise of a favorable mobilization of the joint. Arthroplasty was considered inadvisable when only one joint was stiff, unless there was at the same time marked deformity. The operation was agreed to be positively indicated in cases in which both hips, both knees, or one knee and one hip were ankylosed. It is indicated when both elbows are ankylosed, and is advisable when one elbow is ankylosed in extension. Most of those who took part in the discussion favored the interposition of free flaps of fascia, the function of which was thought to be that of a temporary limiting membrane. Traction was favored as the best method of postoperative fixation. Movement of the joint operated on was best begun after two weeks. In the weight-bearing joints, active use should not be allowed until the end of six weeks from the time of operation. Those of the French surgeons who discussed the subject favored excision to arthroplasty. Putti presented a group of patients who had stable, painless and functioning knees after arthroplasty.

Hey Groves[70] reported the conclusions obtained by compiling the results of twenty surgeons of Great Britain. He found that the elbow has been the joint most frequently operated on and that the knee has been most rarely operated on. Gonorrheal arthritis resulting in ankylosis has been rarely operated on. Successful functional results have followed excision just as frequently as when a pedunculated flap of fascia has been interposed, 41 per cent. in each instance; whereas,

69. British M. J. **2**:142 (July 28) 1923.
70. Hey Groves, E. W.: Brit. J. Surg. **11**:234 (Oct.) 1923.

the use of free fascia as an interposed substance has resulted in 36 per cent. of success. No fatality is reported except in hip operations, in which it has been over 4 per cent. Ultimate results have been best in the elbow, 49 per cent. successful. The hip has shown 23 per cent. success and the knee 21 per cent. In other words, during the past five years, in the hands of twenty British surgeons, the chances of mobilization of a stiff elbow are about equal to the chances of failure; with the hip and knee the chances of successful mobilization fall to one chance in four or five. Hey Groves points out that perfect results have been obtained, but regards them as the exception rather than the rule. He shrewdly observes that so long as arthroplasty can fashion only joints that are lined with fibrous tissue, just so long will the results show a high percentage of failure. He believes that future achievement lies in the direction of replacement of joint cartilages, perhaps by cartilage grafts.

W. R. MacAusland [71] presented a paper on arthroplasty in London. and has republished the same work in two papers in American journals. His work is carefully done and gives an excellent review of the subject of arthroplasty. He adds nothing new to the subject except perhaps his insistence on the necessity for special technical skill on the part of the surgeon who attempts to do arthroplasty—this and the careful selection of patients to be operated on.

[Ed. Note.—We feel that, in these papers and in their discussion, arthroplasty has had a thorough reconsideration. Nothing new has been advanced. In fact, the discussion leads to the opinion that arthroplasty is just where it was a decade ago. We agree with Hey Groves that what is needed is a practicable method which will give a new joint cartilage or a substitute for the same. Until we are able to prevent fibrous ankylosis, we shall not be able to prevent bony ankylosis.]

Internal Derangements of the Knee.—Surls and Osgood [72] have reported an end-result study of 181 cases in which operation was performed for various and sundry internal derangements of the knee. The study was made at the Massachusetts General Hospital. The authors had for their purpose not only the establishment of the end-results of operation in the conditions under discussion, but also the illustration of a method of thoroughness in reporting these end-results. They also suggest a record outline in order that end-results may be better judged. This work is most encouraging in that it shows that

71. MacAusland, W. R.: Surg., Gynec. & Obst. **37**:255 (Sept.) 1923: New York State J. M. **23**:361-369 (Sept.) 1923.

72. Surls, J. K., and Osgood, R. B.: J. Bone & Joint Surg. **5**:635 (Oct.) 1923.

internal knee derangement gives, generally speaking, approximately 90 per cent. success when operations are carefully done. The study reviews the subject under the headings of history, surgical anatomy, etiology, pathology, signs, diagnosis, treatment and prognosis.

Fisher [73] recommends a wider incision and a better exposure of the inside of the joint in internal derangements of the knee. His incision starts high up on the anterior thigh surface and comes down from the top of the suprapatellar pouch to the tibial tubercle. It is not in the midline, but to the inside, so that it skirts the border of the patella. The patella is pushed outward and the joint cavity exposed.

Tavernier [74] gives us a useful reminder that semilunar cartilages may cause the symptoms and signs that are often called sprain of the knee or rheumatism of the knees. There may not be limitation of complete extension or hydarthrosis, but there will be pain at the same spot. He believes in removal of the loose cartilage.

Osteochondritis Dissecans; Osteochondromatosis.—Sommer [75] believes that osteochondritis is a definite disease process of a peculiar character. He believes also that trauma alone will not cause the development of the "joint mouse." It is not only a partial fracture of the articular cartilage, but also has the characteristics of an aseptic degeneration associated with cellular substitution.

Henderson and Jones [76] give us a complete study of eighteen cases, with histories, roentgenograms, and pathologic study of tissue removed. They conclude that the condition has the earmarks of benign neoplasm. Trauma is secondary as a causative factor. The process of formation of the "joint mouse" is an osteochondromatosis of the synovial membrane.

Disease of the Patella.—Johannson [77] calls attention to a change in the lower half of the patella which gives clinical signs and roentgen-ray photographic changes quite similar to those seen in Osgood's disease of the tibial tubercle.

Transplantation of Fascia, Muscles, Etc.—Bertocchi and Bianchetti [78] discuss the results obtained by various surgeons in their attempts to reconstruct the crucial ligaments of the knee and concede that Hey Groves' method has given the best results, using, as suggested to him by Smith, fascia lata for both ligaments. They say nothing is definitely

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73. Fisher, A. G. T.: Lancet **1**:945-949 (May 12) 1923.
74. Tavernier, L.: Lyon Med. **132**:725-729 (Aug. 25) 1923.
75. Sommer, R.: Beitr. z. klin. Chir. **29**:1-60, 1923.
76. Henderson, M. S., and Jones, H. T.: J. Bone & Joint Surg. **5**:400 (July) 1923.
77. Johannson: Ztschr. f. Orthop. Chir. **43**:82, 1922.
78. Bertocchi, A., and Bianchetti, C. F.: Chir. d. org. di movimento **7**:225 (June) 1923.

known as to the final state of the ligaments thus formed, whether the transplanted material lives per se or acts only as a scaffold on which new ligaments are formed. For this reason, the authors instituted a series of experiments on rabbits, making eighteen in all. Their conclusions are as follows: 1. In general terms, it can be stated that autoplastic grafts of fascia and tendons through bones become attached and live by becoming fixed to the host bone, especially from the external fibrous layer of the periosteum, gradually growing into the tissue of the graft while the osteogenetic layer encloses the grafted fascia and tendon at the point of entrance and of exit, new formed bone in the guise of a tubercle of insertion being exuberant in about twenty days, with cartilaginous zones which gradually disappear completely. This justifies the precaution used by Andreini in his attempts at tendon transplants passed through a bony tunnel in which he aimed, by complete thermocauterization of the periosteum and of the bone at points of entrance and exit, to avoid fixation of the transplants from periosteal proliferation. The morphohistologic alterations in their grafts were limited to a little focal necrosis. The calcification and even ossification of the graft was never observed, although it was always enclosed by bone of the host. That is of special interest from the practical results which can be obtained from it, since it demonstrates that a fibrous connective tissue in organic association with bone in the immediate vicinity of dead bone (the margins of the tunnels) and with bone in the process of new formation (the periosteal buttons) maintains its histologic characters; that is, does not become calcified or ossified. This fact is in confirmation of the doctrine that the presence of calcareous salts of bone is not sufficient to produce metaplasia of any connective tissue into bone, which Barth, in his time, believed to have been demonstrated, and, as recently, M. B. Schmid seems to recognize. Further, shortly after the publication of Barth, Morborgo and his students Martini and Donati, with various experiments, invalidated the doctrine of Barth, or at least confined it to narrower limits. 2. The attachment of the grafts of fascia and tendons through joints, according to methods described, is good not only from the morphohistologic point of view, but also from the anatomic functional point of view. While the portion passing through bone is affected as above described, the articular portion remains free, in a good state of preservation, is resistant, is elastic and represents a new fibrotendinous ligament, with excellent dynamic and functional power that is in accord with the clinical results obtained by Groves, Smith, Putti, etc. The alterations in the joint itself through which the graft passes are negligible provided the operative work has been conducted with appropriate technic and with the strictest asepsis. If inflammatory factors do not intervene, the function remains good, with the best power of retention of the new ligament even when, as has been

tried by us, previous to the grafting the crucial ligaments have been removed. 3. In general, it has been noted that the tendon is better adapted for these grafts and for function in the sense that it becomes joined very firmly to the periosteum and realizes the conditions that are adapted for the substitution of strong ligaments such as are the crucial ligaments.

Gallie and Le Mesurier [79] have shown experimentally that strips of living fascia may be used to close gaps in tissue. These fascial strips are threaded into a large eyed needle and the tissue about the gap, deficiency, or ring, and "darned" with them as one darns a sock. The advantages of living tissue as suture material are many. They are not absorbed but become part of the structures in which they are placed. They do not pull out or irritate, nor do they heal by scar tissue formation. They resist ordinary physiologic strain placed on the tissue better than any other type of suture.

Göbell [80] has found free muscle transplants useful in so-called ischemic contracture of the forearm. He takes free flaps of tissue from the abdominal wall or thigh, making an attempt to connect a proper nerve supply. The exact technic is not satisfactorily given. At times, it is advisable to shorten the bones of the forearm in addition to making the transplants.

Tendon Lengthening, Shortening, Rupture, Etc.—Greenwood [81] advises lengthening of the Achilles tendon when it is necessary to perform a tenotomy of this contracted tendon. Often, lengthening does not impair the strength of the gastrocnemius muscle as other methods do. He says that subcutaneous tenotomy performed at two levels with stretching will result in a wide gap, and that nature cannot bridge the 2 to 2½ inch (5 to 6.3 cm.) gaps that are often necessary to correcting adult equinus. The open method is safer and more accurate.

Hauck [82] has reported four cases of rupture of the tendon of the long extensor of the thumb after Colles' fracture. These ruptures took place from two to six weeks after the fracture, when the patient was starting the use of his hand. Suture of the tendon was resorted to, with good results.

Rosenberg [83] has given a clear clinical picture of rupture of the long head of the biceps. In most cases, the injury was slight, well within the limit of ordinary occupational strain. Most of the patients had chronic shoulder arthritis with a thinning of the tendon where it crosses

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79. Gallie, W. E., and Le Mesurier, A. B.: Canad. M. A. J. **13**:469 (July) 1923.
80. Göbell, R. G.: Deutsch. Ztschr. f. Chir. **117**:106 (Jan.) 1923.
81. Greenwood, H. H.: Brit. J. Surg. **10**:483-486, 1923.
82. Hauck, G.: Arch. f. klin. Chir. **124**:81, 1923.
83. Rosenberg: Deutsche Ztschr. f. Chir. **171**:311 (Sept.) 1923.

the margin of the head. In a few cases, traumatism, direct and severe, caused the rupture, but these cases occurred in young and very active persons. In the actual ruptures in young people, suture of the tendon is advisable. In the older and arthritic type, no operation is necessary.

Bursitis.—Hertzler [84] describes a deep bursa, quite distinct from other bursae, situated between the abductor hallucis and the flexor longus hallucis and digitorum. It is seated just in front of the sustentaculum tali. When this bursa is diseased, there is distinct tenderness on pressure just in front of the origin of the flexor group of muscles on the os calcis, with none of the general symptoms of flatfoot. This pain is not relieved by arch supports. Removal of the bursa by operation has given relief in twenty cases.

Bone Transplantation, Fusion, Arthrodesis, Etc.—Albee [85] gives the results of his experience in 3,000 operations in which bone grafts of one or another type were used. His most valuable observations are that the time of operation must be well chosen; cambium layers should come into contact; infection must not be present, and the operation time must be as short as is consistent with good bone carpentry.

Smith [86] has studied the spines removed from ten patients who died long enough after operation for spinal fusion after Hibbs' method to determine the success or failure of the method. He found that fusion of the vertebrae took place in the lumbar spine just as well as in the dorsal spine. He observed that the roentgenogram is not a guide in any sense as to the amount of fusion that takes place in the spine. Fusion was very firm in the cases that came to necropsy. In a series of 221 cases, both of tuberculosis and scoliosis, in which fusion after Hibbs' method was performed, only one spine failed to show satisfactory fusion.

Widerøe [87] has reported two cases of spondylolisthesis on which he performed a combination of Hibbs and Albee operations. He took the graft from the crest of the ilium and fused the lumbar spine. Both patients were relieved of symptoms.

Thomas [88] has called attention to the frequency of natural fusion in scoliosis. In the pathologic specimens of severe cases, it is noted that, on the concave side, there is a process of successful fusion of the

84. Hertzler, A. E.: Inflammation of Deep Calcaneal Bursa, J. A. M. A. **81**:8 (July 7) 1923.

85. Albee, F. H.: Fundamentals in Bone Transplantation, J. A. M. A. **81**:1429 (Oct. 27) 1923.

86. Smith, A. De F.: J. Bone & Joint Surg. **5**:507 (July) 1923.

87. Widerøe, S.: Norsk. Mag. f. Laegevidensk. **84**:640 (July) 1923.

88. Thomas, H. B.: Fusion in Scoliosis, with Special Reference to Anatomy of Natural Fusion and Use of Osteoperiosteal Graft, J. A. M. A. **81**:1575 (Nov. 10) 1923.

vertebral bodies. Thomas believes that the osteoperiosteal graft (Delagenière) used with the Hibbs' fusion operation gives the best promise of fusion.

David [89] has experimented on cadavera in search of a proper route for ankle joint drainage. He finds the posterior external route the best. The joint is easily accessible and no important structures are endangered.

Baer, Bennett and Nachlas [90] have written a report of a group of cases presenting psoas abscess which had origin in the pelvic lymphatics or the retroperitoneal lymph glands. It is important to recognize the fact that many psoas abscesses may not come from the bones of spine or pelvis. The authors point out that retroperitoneal lymph glands exist with either tuberculosis or sepsis and that these conditions should be differentiated from spinal or pelvic bone disease with abscess.

Sandelin [91] reports on hallux valgus in Helsingfors. On examination of 3,200 persons, he found hallux valgus present in 30 per cent. There were three women affected to every two men. In 150 cases in which operation was performed, there were nine women to one man. In 107 patients, 202 operations were performed, 182 being resections of the head of the first metatarsal, the Hueter operation, and the remainder excision of the so-called exostosis. The anatomic and functional result was excellent in 88 per cent. of the cases. In 10 per cent., it was moderately improved. The Hueter operation, or resection of the first metatarsal head, did not favor the development of flatfoot.

Engel [92] reports from Gocht's clinic that Hueter's operation for hallux valgus has given excellent and lasting results.

Lowman [93] believes that certain types of feet, despite long and carefully applied corrective procedures, persist in assuming a bad valgus position, with marked depression and flattening of the arches. Flatfoot of the congenital type which has gone on for ten or twelve years, with the history of weak ankles, certainly presents a serious problem. Among the etiologic factors in this condition are faults of leg alinement; faults in nutrition, and lowered muscular and ligamentous tone, and faults in tarsal development. Tibial torsion, bowleg and knockknee are the chief factors that produce a faulty inward thrust on the foot. There is frequently seen a type of scaphoid which is almost crescentic. The scaphoid is the last of the tarsal bones to appear. If the scaphoid bone

89. David, S. P.: J. Bone & Joint Surg. **5**:480 (July) 1923.

90. Baer, W. S.; Bennett, G. E., and Nachlas, I. W.: J. Bone & Joint Surg. **5**:590 (July) 1923.

91. Sandelin, T.: Acta chir. Scandinav. **56**:1 (July 5) 1923.

92. Engel: Arch. f. Orth. **21**:437, 1923.

93. Lowman, C. L.: Operative Method for Correction of Certain Forms of Flatfoot, J. A. M. A. **81**:1500 (Nov. 3) 1923.

does not fill in and harden rapidly enough, it fails to block out the length of the inner aspect of the foot, and the astragalus, which appears at birth and is growing rapidly, has to elongate to make up the deficiency. In so doing, it is allowed to sag down. Another fact of real importance is the direction of pull of the anterior tibial muscle. A curved incision is made, base downward, extending from just below the inner malleolus upward and forward to a point above the scaphoid, and thence forward and downward to a point on the inner aspect of the base of the first metatarsal. A wedge is excised from the scaphoid, also from the head of the astragalus, base downward and inward. If the Achilles tendon is too much shortened, it is lengthened rather than tenotomized. If it is a simple, nonparalytic flat-foot with fairly strong tibials and not much overaction of the peronei, the latter are simply tenotomized. Then the anterior tibial tendon is isolated down to its attachment, and it is displaced inward and downward until it slips over the squared-off corner of the scaphoid, thus passing through the opening made by the osteotome. It is not detached, however, but its direction is altered, so that, in pulling upward, it raises the scaphoid or keystone. The tendon of the anterior tibial should be held down under the scaphoid while the operator places a deep suture of fine kangaroo tendon strongly in the middle of the calcaneonavicular ligament and passed around, not through, the anterior tibial tendon, the assistant making strong correction of the arch while it is tied. In cases of marked overaction of the peronei, the peroneus longus may be brought across the front of the ankle under the annular ligament by way of the sheath of the anterior tibial tendon, directly downward into the gap between the astragalus and scaphoid. In most of the more serious older cases of congenital structural flat-foot, only one foot should be operated on at a time. The patient can be up sooner and has one reasonably useful foot to walk on while breaking in the new one. If the worse foot has been operated on first and not quite so good a position gained as might be desired, it can be further manipulated when the other foot is operated on.

Lord [94] is thoroughly convinced of the rôle of the os calcis in the production of flat foot. He has had fourteen sufficiently severe cases in which he has operated by a method similar to that of Gleich. This operation, osteotomy of the os calcis and displacement inward of the posterior fragment, changes the line of weight bearing inward sufficiently to throw the balance of weight bearing to the outer side of the center of gravity, and relieves the longitudinal arch. The technic consists of a curved incision, a finger's breadth behind the external malleolus. A

94. Lord, J. B.: Correction of Extreme Flatfoot; Value of Osteotomy of Os Calcis and Inward Displacement of Posterior Fragment (Gleich Operation), J. A. M. A. **81**:1502 (Nov. 3) 1923.

thin, broad chisel is driven obliquely through the bone, the lower edge of the chisel held 1 cm. or more forward. The posterior fragment of bone becomes so easily mobile, after being pried loose, that it is easily held in the desired degree of correction, as the plaster is applied. Plaster casts in varus are applied for four or six weeks, then adhesive strapping. From six to nine months' disability may be expected in bilateral cases. It should not exceed from three to six months in unilateral cases. The results of various modifications of the Gleich operation, as reported by others, have been excellent. It sometimes takes as long as a year, but the result is a good pedal arch.

[ED. NOTE.—We feel that certain types of painful rigid feet should be operated on. Both Lowman and Lord indicate possible measures of operative relief. It seems probable that the arthritic type of flatfoot will be best treated by one or another type of tarsal fusion. This operative treatment should be considered only after a searching analysis of clinical data and a failure of nonoperative measures.]

Fractures in Transplanted Bone.—Haas,[95] in an interesting series of experiments carried out on dogs, attained the following results: 1. Fractures in transplanted bone, even when buried in muscle, united firmly and in a similar manner to a fracture under normal conditions. 2. Fractures in boiled transplanted bone never united or showed any signs of proliferation or attempt at repair. Occasionally a small area resembling new bone was noticed on the surface, which bore no relation to the fracture and was possibly of metaplastic origin. 3. Fractures in transplanted bone in which one half was boiled and the other half was alive, even when buried in muscle, under favorable conditions united. It is believed that this is the crucial test of the independent inherent osteogenetic power of the cells of a transplanted piece of bone and establishes beyond doubt the proof of this independency, and furthermore shows as additional reparative property of these same osteoblastic cells.

Haas[95] performed twenty experiments on ten dogs to see if there was viability of bone after removal for a certain length of time from the body. He removed sections of bone, fractured it and kept it in a sterile bottle and also in salt solution; and later, put these bones into the back muscles of the dog. From the results of these experiments, he concludes that: 1. The osteoblastic cells of bone survive an exposure period of nineteen hours in air at room temperature. 2. There is sufficient active retained vitality in the exposed cells to form callus and in some instances union of a fractured bone after its transplantation into a muscle of the same animal, independent of any other source of osseous

95. Haas, S. L.: Surg., Gynec. & Obst. **36**:749 (June) 1923; Study of Viability of Bone After Removal from Body, Arch. Surg. **7**:213 (July) 1923.

elements. 3. The demonstration of the survival of the cells of the bone after removal from the host adds uncontroverted evidence that the osteoblastic cells of a bone graft play an independent active rôle in the processes of regeneration.

Lime Salts in Growing Bone.—Rabl [96] has studied the lime salt content of growing bones in pig embryos and human infants. He has used both histologic and chemical methods. His observations cover enchondral bone, and periosteal bone, and the metaplastic development of bone. His article gives his technic and detailed findings. Eden has been stimulated by this research of Rabl to inject a 2 per cent. solution of sodium acid phosphate into a callus at the seat of fracture and has found that it caused the callus to solidify with greatly increased rapidity. Rabl's work deserves the careful consideration of those interested in bone surgery.

Fournier [97] reports several cases of bipartite patella. The accessory centers consisted of one or more small nodules disposed eccentrically and peripherally to the main nodule. Roentgen-ray examination of the opposite leg in most of the cases showed that the condition was bilateral. Study seems to show that these secondary nodules develop from accessory centers of ossification and that these may fail entirely to fuse with the main fragment or be joined to it incompletely by a small bony bridge, or that they may fuse, in which case they cause irregular projections from the main nodule. In fact, the presence of secondary ossification centers for the patella has been demonstrated in several instances. The clinical importance of the condition lies in the possibility of considering it a fracture, particularly when the roentgenogram is made on account of an injury. There is also a possibility of an apophysitis developing here during the growth period, just as in the case of the tibial tubercle. Mouchet has seen two cases in which this condition was apparently its cause. They were accompanied by hydrarthrosis and promptly recovered with fixation of the knee. Fournier considers that removal of the accessory nodule is rarely required.

FRACTURES

Fracture of the Humerus.—Block [98] recommends the use of direct skeletal traction in cases of severe fracture of the humerus when the usual extension measures have proved insufficient. He passes slender steel pins through holes that are drilled horizontally in the acromion and in the lower end of the humerus. The projecting ends of the pins are then connected to a steel frame fitted with a screw-lengthening device, by means of which extension is obtained.

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96. Rabl, C. R. H.: Klin. Wchnschr. **2**:1644 (Aug. 27) 1923.
97. Fournier, J.: Rev. d'orth., September, 1923, p. 393.
98. Block, Werner: Klin. Wchnschr. **2**:2036 (Oct. 29) 1923.

[Ed. Note.—While we have had no personal experience with skeletal traction in fractures of the upper extremity, we must confess a certain feeling of apprehension in regard to its use in this region. The conditions here are different from those in fractures of the lower extremity, and open reduction offers a fairly simple and safe solution in difficult cases. In endeavoring to avoid this by the use of skeletal traction, one has not far to go until the alternative procedure actually exceeds in severity the method which one is trying to escape.]

Fracture Dislocation of the Spine.—Thompson,[99] writing on the subject of fracture dislocations of the vertebrae, opposes routine operation for the relief of cord compression. He states that it is often unsafe, rarely justifiable and usually futile. Except in rare instances, when median incision of the cord is the objective, mere exposure of the injured segment is all the surgeon can hope to accomplish. Deformity is seldom persistent, and massive hemorrhages do not occur. He considers that the only positive indication for operation is the presence of deformity of such degree as to justify the assumption that the cord is being subjected to pressure. Even with such strict limitations, incomplete lesions alone would be benefited. If it were possible to distinguish with certainty complete from incomplete lesions in the early period, the problem would be solved. At the present time, we are unable to decide, and consequently we must either wait days or weeks for unequivocal signs or operate early, with little chance of affording relief. Waiting, therefore, seems the best and safest course.

Kümmel's Disease.—Jones [100] reports a case of Kümmel's disease, and analyzes the literature. He concludes that the condition constitutes a separate entity, and is not simply a crush fracture of the vertebral body. The basic origin is a trauma, which may be mild or severe, but is sufficient to start a spondylitis and subsequent atrophy of the bony framework with collapse of the vertebral body. Roentgenologic examination reveals no demonstrable change immediately after injury, but after several months or even years a collapse and compression of the body of the vertebra may be seen. The prognosis depends on the early recognition of the disease and the use of adequate fixation, either by employment of plaster-of-Paris jackets and immobilizing apparatus or by an ankylosing operation on the spine.

[Ed. Note.—We would also observe that even when operative treatment is employed, long continued fixation is required.]

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99. Thompson, J. E.: Ann. Surg. **78**:260 (Aug.) 1923.

100. Jones, Fosdick: Compression Fractures of Spine Developing Delayed Symptoms (Posttraumatic Spondylitis, or Kümmell's Disease), J. A. M. A **81**:1860 (Dec. 1) 1923.

Burdick and Siris,[101] after a study of 268 cases of fracture of the femur in children below the age of 13, reach the following conclusions: Fracture of the femur in children is almost invariably followed by a good functional result. A satisfactory anatomic reduction is not essential for perfect function. Under the age of 6, such cases are best treated by Bryant's method of overhead suspension; above the age of 6, by the application of a plaster spica with traction. Suspension treatment in a Hodgen or Thomas splint is not practicable except in cases of compound fracture or of simple fracture with laceration or severe trauma to adjacent tissues; when the administration of an anesthetic is contraindicated, or when skeletal traction is to be employed. The majority of cases in which patients are discharged with shortening will be spontaneously corrected within one or two years. In a certain number of cases, irrespective of the form of treatment, the injury will be followed by an actual lengthening of the affected leg. Open reduction is rarely indicated, as almost any type of deformity may be corrected by skeletal traction.

[ED. NOTE.—We are able to agree with practically all of the conclusions of the authors, except the conclusion that, in children above the age of 6, the best method of treatment is by reduction with traction and fixation in a plaster spica. We have definitely abandoned this procedure in favor of treatment by the method of continuous extension in a small, snugly fitting Thomas splint for a period of about four weeks, and we are convinced that our results have been considerably improved thereby. Skeletal traction is rarely required in cases of simple fracture in children.]

Fracture of the Neck of the Femur.—Valtancoli,[102] who has made a statistical study of 164 cases of fracture of the femoral neck at the Rizzoli Institute, finds that this injury occurs with notable frequency in youth, and that 19.4 per cent. of the patients were under the age of 30. In the total number of cases, there was nearly an equality between fractures confined to the neck and those involving the neck and trachanter. In infancy and up to the thirtieth year, the central type of fracture is the more common. In the fourth and fifth decades, the frequency of the two varieties is about equal. In the sixth decade, the fractures of the neck occur more commonly; while in the eighth decade, fractures involving the neck and the trochanter are again in the majority. He finds that retardation or entire lack of consolidation is observed with great frequency in fractures of the neck in every epoch of life.

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101. Burdick, C. G., and Siris, I. E.: Ann. Surg. **77**:736 (June) 1923.
102. Valtancoli, G.: Chir. degli Org. di Movimento **7**:551-556 (Oct.) 1923.

In contrast to the foregoing, as representing the American point of view, is Campbell's [103] report on his study of end-results in the same type of injury. His experience covers a series of 227 cases. Of these, sixty-seven were old ununited fractures; and of interest as showing the difference in prognosis between fractures of the central portion of the neck and those of the base of the neck is the fact that, in this group, there was not one single case of the latter type, but all were of the central variety. The remaining 160 cases were all fresh fractures, of which ninety-nine were central or intracapsular, while sixty-one were in the trochanteric region. The Whitman method of reduction was used in all cases with plaster-of-Paris retention. Of 205 elderly patients so treated, only ten died, or 4.4 per cent. Campbell observes that no final conclusion as regards union can be reached before the lapse of a long period. Roentgenologic evidence is of no value before the end of one year. He has had one case in which apposition of the fragments was demonstrated at the end of six months, only to have separation occur under the influence of unprotected weight bearing. Clinical evidence is also of little value at an early period. A patient with nonunion may be able to lift the heel from the bed, as Campbell has proved at operation. In order to ascertain the end-results as regards union, Campbell undertook a study of old cases, but in order that a fair conclusion might be reached, certain limitations were imposed. No case was accepted for study until after the lapse of fifteen years from the time of injury, or which did not show a typical complete fracture of the central type as determined by the original roentgenograms, or in which the patient would not come to the hospital for roentgenologic examination. Only twenty-one cases fulfilled these requirements. The results were as follows: nonunion, one; fibrous union, two; doubtful, two; bony union, sixteen. In the two classed as doubtful, there was good function and no change in the angle of the neck after fifteen months, probably bony union. Of the two with fibrous union, one patient walked with only slight limp and no disability, the other was unable to walk without crutches. Of the sixteen with bony union, eight walked perfectly, five had a slight limp and three walked with one crutch, at the end of fifteen months. Seventy-five per cent. had solid union, 90 per cent. had excellent function and in 10 per cent. there was nonunion. Campbell operated in twenty cases of ununited fracture, a bone graft from the tibia being driven upward through the trochanter into the central fragment. Of these, fourteen were successful, two failed, one improved, and three are too recent to allow any conclusion. He believes that, in these cases, union cannot be produced after extreme atrophy has occurred, but

103. Campbell, W. C.: Fracture of Neck of Femur, J. A. M. A. **81**:137 (Oct. 20) 1923.

success may be obtained in practically all cases in which operation is performed within one year of the time of injury.

[ED. NOTE.—Campbell's report is very convincing, affording a basis for the optimism which we share with him in regard to this fracture when properly treated. A factor of undoubted importance in relation to bony union is that of age, and it would be interesting to know the age of the patients mentioned above. As the chief problem is constituted by patients who are 70 or over, we must learn whether the results justify the ordeal which the Whitman procedure constitutes for feeble patients who at best have only a feeble span of life before them.]

Fracture of the Patella.—Sacco,[104] from the Rizzoli Institute, advocates the operative treatment of fractures of the patella and the use of metal screws for fixation of the fragments. He reports excellent results in eighteen cases treated by this method. Movement of the joint was begun within a few days and active weight-bearing was permitted at the end of one week.

That this method does not meet with unanimous approval among Italian surgeons is shown by the articles of Cignozzi,[105] Tremiterra[106] and Tritto,[107] all of whom advise operation only under exceptional conditions. They are well satisfied in the average case with the results of bloodless methods of treatment.

[ED. NOTE.—The publication of three articles by surgeons from the same country at approximately the same period, all of which strike a conservative note in regard to the operative treatment of fractures of the patella, seems more than a coincidence. If this represents a general trend of Italian medical opinion, it is interesting to note that fact at least, but it would be of still greater interest to know the cause.]

Stieda's Fracture.—Schüller and Weil[108] oppose Stieda's view that the lesion which the latter author has described actually constitutes a fracture of the medial condyle of the femur. The condition occurs as the result of injury to the inner side of the thigh and is attended by persistent pain and tenderness in that region. Roentgenologic examination reveals a small, sickle-shaped bony shadow lying close to the medial condyle. Schüller and Weil believe it is caused by calcification in the tendon of the adductor magnus muscle, and they have been able to corroborate their view by the injection of an opaque substance into the tendon. Subsequent roentgenologic study revealed that the body was actually in the tendon. In one case, they have been able to make

104. Sacco, R.: Chir. d. org. di Movimento **7**:257 (June) 1923.
105. Cignozzi, O.: Chir. d. org. di Movimento **7**:579 (Oct.) 1923.
106. Tremiterra, S.: Riforma Med. **39**:296 (March 26) 1923.
107. Tritto, G.: Riforma Med. **39**:895 (Sept. 17) 1923.
108. Schüller, M. P., and Weil, S.: Beitr. z. klin. Chir. **129**:71, 1923.

a histologic study of the tissue, and this has convinced them that the process is one of metastatic ossification. The causative factor is generally not a direct trauma, but a strong incoordinated contraction of the adductor magnus muscle, as the result of which the tendinous insertion becomes strained.

Healing of Fractures.—Albanese,[109] from the Institute of Clinical Orthopedics of the University of Rome, reports the results of some interesting investigations which he has conducted to determine whether Wolff's law holds good in the healing of fractures. For the purpose of study, he fed or injected the animals with a preparation of alizarin, which stains only new forming bone tissue. In this way, he was able to study the consolidation of fractures with especial reference to the structural changes. His conclusions in general are: Two forms of consolidation take place, anatomic and functional. Anatomic consolidation, which is simply a union of the fragments and is accompanied by bone changes only in the immediate vicinity of the fracture, occurs very early. Functional consolidation in case of malposition of the fragments requires a long time and is completed only when changes have occurred in the skeletal segment so that its bony structure has adapted itself to the new alignment of strains incident to the change in the alignment of the fragments. The author believes this fact accounts for the long period required for the restoration of function after certain fractures. He believes these changes occur in general in accord with Wolff's law.

French Military Organization for the Handling of War Fractures.—Duget [110] of the French Army Medical Service, speaking before the Association of Military Surgeons of the United States, explained the present medical organization in the French Army for treating cases of bone and joint injury in case of war. Immediate splinting is required in all such cases on the field. In order to standardize and simplify the apparatus, four types of splint have been adopted. 1. The gutter splint of Jeanbran. This is a malleable aluminum splint for the upper extremity. 2. The Thomas splint as modified by Lardennois, with an attachment to immobilize the hip joint. 3. The apparatus of Pouliquin (not described). 4. External wooden splint (not described). Special hospitals have been created for care for bone and joint injuries, to function in the intermediate zone between the front and the base in connection with each army corps. The importance of such an organization has been emphasized by the casualty figures during the World War. These show that compound fractures constituted 7.6 per cent. of all wounds; that they require from 14 to 17 per cent. of all major surgical interventions, and that death may result in 50 per cent. of cases of fracture of the femur.

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109. Albanese, A.: Policlinico **30**:337-352 (July) 1923.
110. Duguet, M. L. F.: Mil. Surg. **53**:574 (Dec.) 1923.

DISLOCATIONS

Recurrent Dislocation of the Shoulder.—Bankhart [111] believes that the cause of recurrent habitual dislocation of the shoulder may be found in the fact that the original dislocation which leads to the development of the condition is produced by a mechanism different from that of hyperabduction. According to this conception, direct violence acting from behind is the causative factor, the head being displaced forward and tearing the capsule loose from the glenoid ligament or avulsing the latter from the bone. When reduction is brought about, there is lack of approximation of these structures, and firm healing does not occur. A permanent defect results which favors recurrence of the displacement. The ordinary plication operation does not remedy this condition, but merely takes up the loose capsule and tends to stretch the weakened portion. Similarly, the Clairmont Ehrlich operation, which transplants a flap of the deltoid muscle under the head, is illogical, as it does not prevent displacement anteriorly. Bankart has found corroborative evidence of his view in several cases in which roentgenologic examination showed a concomitant fracture of the greater tuberosity or of the rim of the glenoid. He has found additional proof by direct examination of the capsule at operation. A different surgical approach is necessary in order to reach the affected portion of the capsule. Bankart operates thus: With the patient in the dorsal decubitus position and the arm adducted to the side and internally rotated, an incision is made from the coracoid, outward along the clavicle, and down the arm a distance of from 5 to 6 inches (12.5 to 15 cm.). The deltoid and pectoralis major muscles are separated from each other, and, if necessary, a portion of the latter muscle is divided. The coracoid is next exposed and its tip with the insertions of the short head of the biceps, coracobrachialis and pectoralis minor muscles intact is divided and retracted downward. This exposes the front of the shoulder joint covered by the tendon of the subscapularis muscle. The latter is now divided, and the capsule of the joint, the edge of the glenoid and the neck of the scapula are then easily seen. The avulsed edge of the capsule, with an area of scar tissue corresponding to the defect, can be readily seen. The edge of the glenoid is freshened and the torn edge of the capsule pulled down and sutured to the glenoid ligament with nonabsorbable material. The tendon of the subscapularis is then resutured, the coracoid process replaced and fixed and the wound closed. The arm is immobilized by the side for a period of four weeks, when movement is begun. Bankart has operated in four cases in this manner, with excellent return of function and no recurrence for over one year.

111. Bankart, A. S., Blundell: Brit. M. J. **2**:1132 (Dec. 15) 1923.

Dislocation of the Carpal Semilunar Bone.—Davis,[112] in a well illustrated article, divides cases of dislocation of the semilunar into three classes, and advises treatment as follows: Class 1. Fresh cases in which the condition is recognized immediately. In these, he believes reduction can be accomplished almost always by manipulation. This is done in conformity with Gunn's Law, which states that the limb must be placed in the position it occupied at the time of injury and force exerted on the displaced bone in the reverse direction to that which caused the dislocation. To prevent the semilunar from turning over during the manipulation, Davis places the handle of a broomstick on the volar surface at the proximal tip of the semilunar, and by first hyperextending and then flexing the wrist over it, brings pressure to bear directly on the displaced bone. Class 2. Cases in which the dislocation has not been recognized for a number of weeks or months, or in which manipulation has been unsuccessful. These should be treated by open reduction. Davis uses a dorsal incision, through which a special skid is introduced to hook the bone back in position. Class 3. Old cases which have not been diagnosed; in which the patients have refused operation, or in which, dislocation having existed for a year or more, open reduction has failed. In this group, and only when the case belongs to this group, the semilunar bone should be removed.

BOOK REVIEW

THE TREATMENT OF FRACTURES IN GENERAL PRACTICE. By C. MAX PAGE and W. ROWLEY BRISTOW, Oxford University Medical Publications, London, 1923.

This volume is written as a practical manual for the general practitioner and hospital intern, and the procedures which it describes are, in the main, those which can be carried out by the relatively inexperienced and without the necessity of elaborate apparatus. The treatment in general conforms to the plan which was drawn up by a committee of the staff of St. Thomas' Hospital, London (of which the authors were members) for the benefit of the interns and resident surgeons at that institution. The volume consists of 239 pages with 167 illustrations and covers all the common fractures, including those of the pelvis, thorax, skull, spine and the bones of the face, with additional chapters on general topics. The descriptions of the lesions are accurate, but necessarily sketchy on account of the limited space. The attempt has been made in each case to outline the entire program of treatment up to and including the convalescent stage. Many of the splinting methods advocated are those which were introduced during the war, and we are inclined to doubt whether the average practitioner has as much general knowledge of their use and possibilities, as is evidently presupposed by the authors. Nevertheless, we believe they have succeeded in producing a handy guide, which will prove of much real value to the class of physicians for whom it is intended.

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112. Davis, G. G.: Surg., Gynec. & Obst. **37**:225 (Aug.) 1923.

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